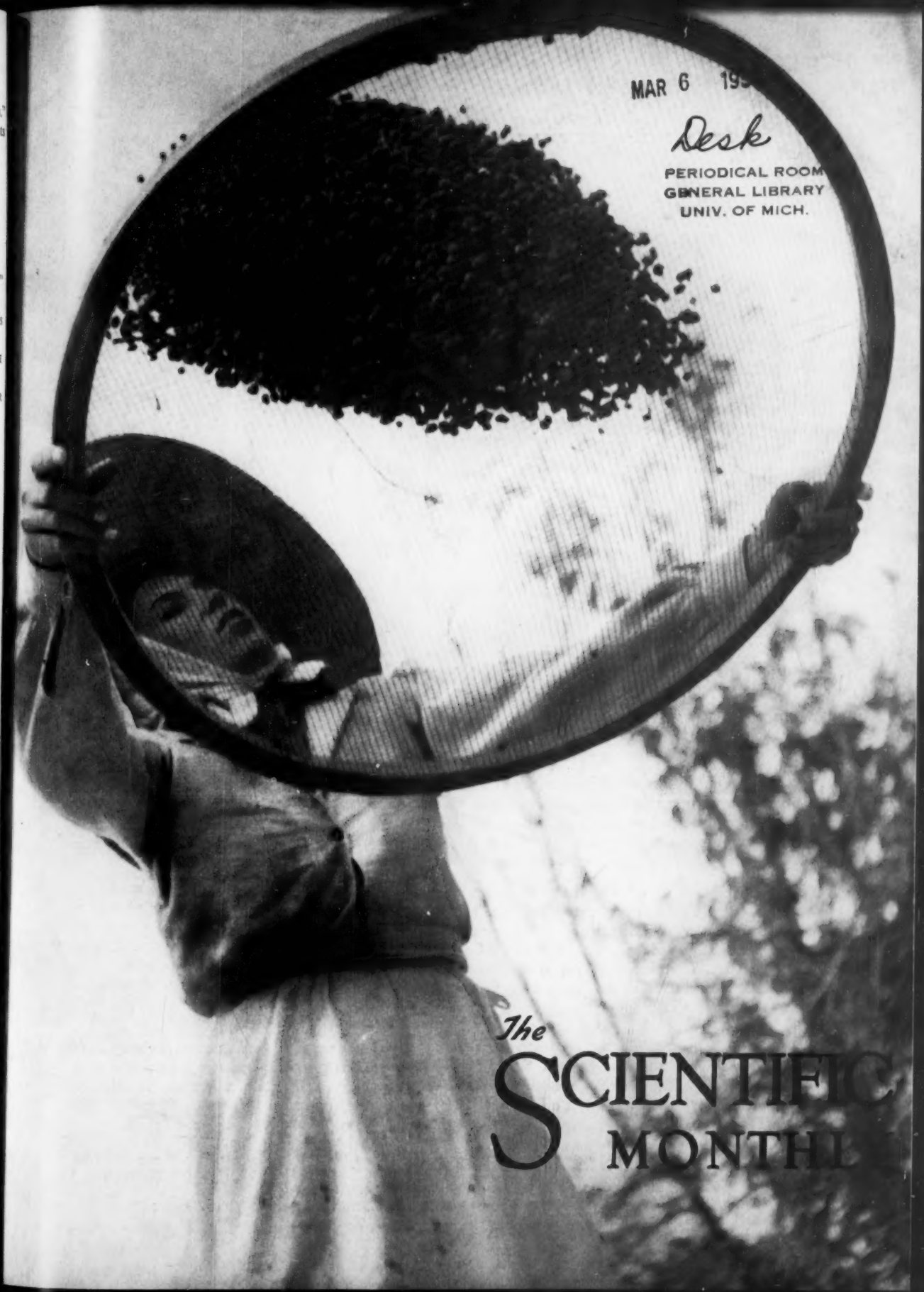

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The SCIENTIFIC MONTHLY

LXX NO 3 MARCH 1950

IT'S DONE WITH MIRRORS!

Protected by a wall of lead bricks and using a mirror to guide his instruments, this Bell Laboratories scientist is preparing a solution of a radioactive isotope, for use as a tracer to study materials for your telephone system.

Bombardment by neutrons turns some atoms of many chemical elements into their "radioactive isotopes"; these are unstable and give off radiation which can be detected by a Geiger counter. Chemically a "radioactive isotope" behaves exactly like the original element. Mix the two in a solution or an alloy and they will stay together; when the Geiger counter shows up an isotope, its inactive brother will be there too. Minute amounts beyond the reach of ordinary chemical methods can be detected—often as little as one part in a billion.

The method is used to study the effect of composition on the performance of newly developed germanium transistors—tiny amplifiers which may one day perform many functions which now require vacuum tubes.

It enables scientists at Bell Telephone Laboratories to observe the behavior of microscopic impurities which affect the emission of electrons from vacuum tube cathodes. It is of great help in observing wear on relay contacts. And it may develop into a useful tool for measuring the distribution and penetration of preservatives in wood.

Thus, one of science's newest techniques is adopted by Bell Laboratories to make your telephone serve you better today and better still tomorrow.

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EXPLORING AND INVENTING, DEVISING AND PERFECTING,
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THE SCIENTIFIC MONTHLY

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Science and Technology

(From the Month's News Releases)

New Publications

How to Get the Job, by Mitchell Dreese. 48 pp. Single copies, 60¢; special rates for quantities. Write to Science Research Associates, 228 S. Wabash Ave., Chicago.

The Story of Forests. 30 pp. Free from American Forest Products Industries, 1319 Eighteenth St., N.W., Washington 6, D. C. May be used with filmstrip of the same name; available to teachers.

The Earhart Plant Research Laboratory, by F. W. Went. 18 pp. Chronica Botanica, Waltham, Mass.

Never Too Old. 216 pp. A report of the New York State Joint Legislative Committee on Problems of the Aging. May be obtained free from Senator Thomas C. Desmond, 94 Broadway, Newburgh, N. Y.

Abrasives, Their History and Development. Norton Company, Worcester 6, Mass.

Training Rural Leaders. 136 pp. An FAO report of a significant educational development in Northwest China.

Studies in Business and Economics: Harford County, Maryland. 28 pp. Bureau of Business and Economic Research, University of Maryland, College Park.

Measurements of Radioactivity, by Leon F. Curtiss. 84 pp. Illus. 35¢ from Supt. of Documents, GPO, Washington 25, D. C.

Leeds & Northrup Bibliography of Polarographic Literature (E-90 (1) 1950). An up-to-date listing of 2,208 references, in chronological order, from the earliest associated work in 1903 up to the middle of 1949. All references are cross indexed alphabetically by authors and by subject. Single copies free on request to 4935 Stenton Ave., Philadelphia 44.

A Four Year Report. Illus. 127 pp. By the Office of Military Government, Berlin Sector, from July 1, 1945, to September 1, 1949.

Vitamin B_{12}

Merck & Co. has announced the availability of vitamin B_{12} in bulk form as the crystalline solid in 25-mg, 100-mg, and 500-mg ampuls. These quantities should make possible extensive chemical, pharmacological, and clinical studies.

Guides

The Methuen Physical Monograph Series, written by prominent British and continental specialists, will soon be distributed in this country by Wiley & Sons. Intended to provide nonspecialists with an understanding of various aspects of physics of interest to contemporary scientists, these monographs are pocket-size, hard-bound books of 64–132 pages, and will probably retail under $2.00. Wilson's *X-Ray Optics,* Jackson's *Low Temperature Physics,* and Beeching's *Electron Diffraction* are three of the titles to be made available.

The *Schering Pharmacists' Income Tax Guide for 1950* (95 pp.) and the *Schering Physicians' Income Tax Guide for 1950* have been prepared by tax experts and are free on request to Schering Corporation, Bloomfield, N. J.

Water

The U. S. Geological Survey has presented to Congress a review of some fifty areas of the United States where the supply of suitable water for household, industrial, or agricultural use could become serious or is already critical. With adequate hydrologic investigation, the Survey says, water shortages can be met intelligently or avoided. The USGS methods and techniques for determining the dependable yield of present or prospective sources of water are available to communities where planning is needed.

Engineers at MIT are studying the possible applications of the so-called analogue computers to make hydraulic engineering predictions faster and more accurately. Out of the research are expected to come new, detailed ways of predicting the behavior of water in all kinds of complicated systems, thus making possible more efficient use of water supplies and water power.

A miniature, portable ion-exchange tower, called the Deeminizer, the first commercial application of a technique of conditioning water developed by chemists of the Rohm & Haas Company, of Philadelphia, is said to deliver up to five gallons of water of a chemical quality obtainable otherwise only through costly triple distillation.

Man's Best Friend

When Mayor D'Alesandro, of Baltimore, Maryland, signed an amendment to the city's dog ordinance on December 17, Baltimore became the twenty-third city in the United States to provide for the experimental use of unwanted dogs in the solving of medical and veterinary problems. Unclaimed dogs will be saved from the gas chamber of the pound operated under contract by the S.P.C.A.

Chemistry

Startling predictions based on the unique properties of fluorine compounds revealed by recent research were made by Professor Earl T. McBee, head of the Department of Chemistry at Purdue, at an ACS symposium in New York City. According to McBee, potential uses of the millions of new fluorine compounds theoretically possible cover the whole range of human welfare. Insecticides, anesthetics, plastics, coolants, lubricants, hydraulic fluids, lubricant additives, synthetic rubber, are among applications mentioned. Only present prohibitive production costs are a barrier to new, large-scale commercial applications.

Plant scientists of the USDA have reported to the American Society of Horticultural Science that recent experiments with orchard sprays with the chemical growth regulator 2,4,5-trichlorophenoxyacetic acid have shown that it can be used to speed up the ripening of apples, sometimes as much as a month. 2,4,5-T also causes the fruit to cling to the trees even after the fleshy parts decay.

Unesco

The Republic of the Philippines makes the fourteenth country in Europe and Asia opened to the CARE-UNESCO Book Program. Loss of at least 5,000,000 volumes—many of them priceless—during the war represented nearly $2,000,000. Most needed in the Islands at present are the latest books on medicine, chemistry, sociology, agriculture, forestry, and engineering.

Representatives of sixteen nations have signed the Unesco-sponsored audio-visual agreement, designed to permit the duty-free movement of educational films, recordings, and other specified teaching materials. It will take effect after ten nations have deposited "instruments of acceptance" or "accession," steps usually requiring domestic legislation.

THE
SCIENTIFIC MONTHLY

MARCH 1950

Ponape: The Cycle of Empire

WILLIAM R. BASCOM*

Dr. Bascom's paper is based on ethnographic field work on Ponape during May–August 1946, carried on as a part of the U. S. Commercial Company's Economic Survey of Micronesia. A member of the staff of the Department of Anthropology of Northwestern University, Dr. Bascom (Ph.D., Northwestern, 1939) has specialized in applied anthropology for several years. Other studies he has made of Ponape are available on microfilm at the Library of Congress.

PONAPE, lying in the Caroline Islands in the Pacific, is an interesting case study in colonial rule. Administered successively by the Spaniards, Germans, Japanese, and, since 1945, by the Americans, it affords an opportunity for comparing the policies of four different powers in dealing with the same group of people, the same body of customs and traditions, and the same economic resources. For all its foreign rulers Ponape has served as adminstrative headquarters for the Eastern Carolines and at times for the most westernly Marshall Islands as well. The available historical records are meager, but it is possible to see the differences in colonial policies through the eyes of the older Ponapeans, who have lived under all four administrations.

Ponape is a high volcanic island, rising to 2,595 feet in its mountainous, cloud-shrouded interior. The rugged interior is uninhabited and is visited by Ponapeans only for wild foods which supplement an economy based on farming and fishing. Breadfruit, yams, and a variety of sea foods are the staple foods. The farms and dwellings are scattered along the edge of the island, which is separated from the ocean by a belt of mangrove swamps, a narrow lagoon, and an encircling reef. Rainfall is heavy. A luxuriant island with a verdant cover, steep gorges, mountain streams, and waterfalls, Ponape is reminiscent of the South Sea islands of Herman Melville. Life on Ponape in the early days, too, seems to have followed the leisurely pace described by Melville in *Typee*. Ponapean hospitality attracted a number of white settlers before the island became a Spanish colony, and Ponapeans remember how, in the Spanish period, before copra production had been established on a commercial basis, the old men used to spend all day racing model canoes.

Although Ponape was discovered during the sixteenth century, the native period of isolation continued until 1827, and its independence lasted for another sixty years. Despite the attempts of American missionaries and German traders to interest their respective countries in establishing colonial rule over the island, Ponape was claimed, by the right of discovery by Spanish explorers three centuries earlier, by two Spanish warships which arrived in 1886. Ponape's history falls into six easily recognizable periods: The native period (before 1827); the pre-Spanish period (1827–86); the Spanish period (1886–99); the German period (1899–1914); the Japanese period (1914–45); and the American period (since 1945).

The pre-Spanish period of early contact was dominated by Americans of two very different types: lusty whalers and puritanical missionaries.

* Acknowledgment for assistance in preparation of this manuscript is made to The Viking Fund, New York City.

Fishing in lagoon from outrigger canoe, and, *right,* packing gill net in canoe.

Ponapean resentment at the early excesses of the whalers, which led to the massacre of the crew of the *Falcon,* has been dimmed by time, and the whalers have become something of a picturesque symbol of virile manhood and of Ponape's period of independence. The Protestant missionaries, on the other hand, are among the best-liked of the foreigners who have dominated Ponape, perhaps ranking even higher than the Germans. Individual missionaries are fondly remembered by name, and there is no question of their good intentions even among Catholics and those who have not given up smoking or drinking kava and alcohol, which were condemned along with many other practices. For almost a century Ponapeans have known better than to expect all Americans to be alike, and, thanks to the early missionaries, the general impression of Americans is very good.

The Spanish period was marked by Catholic-Protestant rivalry, which broke out into serious wars between Ponapeans and government troops and ended with the expulsion of the American missionaries in 1890. Aside from sponsoring the spread of Catholicism and suppressing Ponapean uprisings, the Spanish government had no colonial policy or program. It did not restrict the power of the chiefs or interfere in local affairs, and the Spanish period is remembered today mainly as one in which Ponapean customs continued with little change. As with the whalers, Ponapeans were quick to forgive, and the wars against the Spaniards have been largely forgotten.

The Germans. In 1899 Ponape, along with the rest of the Carolines and most of the Marianas, was sold to Germany after the defeat of Spain in the Spanish-American war. American missionaries were readmitted by the Germans in 1899, but they retired from Ponape again in 1907, when their holdings were transferred to a German Protestant mission. In 1904–05 the Spanish Capuchin priests were replaced by German Capuchins. Following the evacuation of all Germans by the Japanese, the Protestant mission was taken over by Japanese Congregationalists of the South Seas Mission (Nanyo Dendo Dan) in 1920, and Spanish Jesuits were made responsible for the Catholic inhabitants in 1921. Today Ponape is one of the few Micronesian islands which is neither wholly Protestant nor wholly Catholic, being almost equally divided between the two. Protestants are strongest in the South and Catholics in the North, and the early pattern of rivalry has disappeared.

Economic life during the Spanish and German periods was dominated by the Jaluit Company, formed in 1887 by the merger of the three German companies which handled three fourths of the exports from the Eastern Carolines. American whalers had established a brisk trade with Ponapeans for provisions in the pre-Spanish period, and several sailors who made their homes on Ponape set up small trading posts. As whaling declined in the 1860s, German trading ships began to call in the Eastern Carolines to buy copra, and German trading stations were established. Japanese companies operated on Ponape as early as 1893, and,

after having been barred by the German government in 1901 for selling firearms and liquor to the natives, two Japanese companies reappeared in 1905. In 1906 these two companies amalgamated to form "Nambo," or the South Seas Trading Company (Nanyo Boeki Kaisha), which offered increasingly serious competition to the Jaluit Company until the end of the German rule.

The German administration instituted a number of changes restricting the economic privileges of the chiefs and establishing the copra industry as the principal source of money income. According to Ponapean tradition, the ultimate title to all land was vested in the district chiefs, who received tribute in the form of first fruits, feasts, and free labor from the commoners in return for its use. Although tenure was actually based on individual ownership of the crops planted on the land, the commoners enjoyed considerable security. By planting breadfruit or coconut trees on his farmstead, a man acquired exclusive rights to it for his lifetime, provided he fulfilled his obligations to the chiefs, and his rights could be inherited by his heirs and extended by planting new trees.

The boundaries of all farmsteads were adjusted by the Germans to allow sufficient land for copra production, and each family was required to plant one hundred coconut trees. Not only did all families comply with this regulation, but many planted several hundred trees. Deeds to the land were then issued, giving the occupants private ownership of their farmsteads and limiting the number of obligatory feasts and the amount of free labor to be performed for the district chiefs. Chiefs furthermore were not permitted to exile commoners for failing to bring first fruits or to observe the taboos which set the chiefs apart from and above the commoners. Patrilineal inheritance of land was specified, and the division of land among several heirs was prohibited. This last provision, which was contrary to traditional Ponapean custom, was intended to prevent heirs from inheriting several small plots of land too widely separated to be economically farmed. The objective of all these regulations was to insure that each family would have enough land to provide a money income from copra adequate for the purchase of its requirements of imported goods, while satisfying its needs for food through subsistence agriculture.

The German period was one of economic development, marred by another outbreak of violence in 1910, which was suppressed only after German troops and warships had been summoned from New Guinea. Although this outbreak has been interpreted as a protest against the German economic reforms, Ponapeans today give another explanation. They also freely express their gratitude to the Germans for having established what has been their most reliable source of money income with which to purchase clothing, kerosene, and other imported goods on which they have become dependent. In the minds of the older people, the Germans rank with the American missionaries as a group who were trying to do good for Ponape. Besides "dividing the land," they improved the roads and introduced kapok, cotton, rubber, and an improved breed of milk cattle for native use. The Germans gave Ponape a paternalistic but enlightened administration that compares favorably with colonies in other parts of the world. It is said that the German government planned to make Ponape the show place of the Pacific, and there is reason to believe that it might have succeeded if it had remained in power.

Except for Governor Boeder and the German overseer responsible for the outbreak in 1910, the Germans were well liked and respected as individuals because they were just, courteous, neat and well dressed, and versatile in their accomplishments. They took off their hats to Ponapean women; they appeared in public in full uniform; and they were able to build a road, run a boat, make a speech, grow copra, or repair an engine with equal proficiency.

The Japanese. In October 1914 the German administration surrendered to the Japanese Navy. Until the withdrawal of the naval garrison in 1922, two years after the Carolines were mandated to Japan under the League of Nations, the island was ruled by a military government. Japanese rule lasted longer than the Spanish and German periods combined, and passed through two phases. Until 1930 Ponape enjoyed a mild, enlightened administration according to mandate principles. After 1930, and increasingly following Japan's withdrawal from the League of Nations in 1935, the emphasis of Japanese rule shifted to Japanese-owned industry and colonization by Japanese and Okinawan immigrants.

In the first phase native copra production expanded, encouraged by government subsidies to Ponapean farmers. Education, which had been in the hands of the Protestant missionaries since the first school was opened, shortly after 1852, was gradually taken over by the government as the Japanese established public schools. Communication difficulties prevented universal education in the outlying atolls, but nearly all Ponapean children completed the regular three-year course, in

which almost half the time was devoted to the study of Japanese. In 1935 the regular course was made compulsory for all children. Today most Ponapeans speak Japanese, and only a few older people remember German, English, or Spanish. Undismayed by the fact that they have had to learn four different foreign languages in succession, or the fact that all the Japanese they have learned is of no help in communicating with their new American rulers, Ponapeans today are eager to learn English, now that the cycle has been completed.

All German traders were interned in 1914 and later evacuated, with the German missionaries, and other foreign companies were effectively discouraged by the Japanese. Trade was completely dominated by Nambo until the appearance of "Kohatsu," or the South Seas Development Company (Nanyo Kohatsu Kabushiki Kaisha), which controlled the sugar industry on Saipan. Nambo, in 1930, began to develop a former German coconut plantation in addition to its import-export business. In 1934 Kohatsu opened a large plantation, which was converted to sugar and alcohol after an unsuccessful trial with cassava. Rivalry between these two large companies led to a rapid expansion of both plantations into the unoccupied lands lying between them, until they were merged into a single company about 1942. One of Kohatsu's subsidiaries established bonito fishing and ice production, and smaller Japanese companies exported lumber, fibers, tannin, and drugs, and operated a hydroelectric plant, sawmills, a paper factory, bonito fisheries, and other enterprises.

Colonization brought its advantages. Colonia had electric lights, telephones, ice, restaurants, and bakeries, and stores stocked with a wide variety of imported goods to supply the Japanese community. All ordinary goods available in Japan could be purchased on Ponape. Prices were cheap, though Japanese goods were recognized by Ponapeans as inferior to American and German goods. Transportation on Ponape and to the neighboring islands was frequent and inexpensive. Later, Japan's wartime needs led to the development of new Ponapean industries in fibers, tannin, and drugs, and native income from exports increased two- or threefold between 1936 and 1940. Just before Pearl Harbor, Ponapeans experienced their greatest period of prosperity and their highest standard of living.

Nevertheless, the older Ponapeans disapproved of the immodest Japanese habits of dress, particularly because Ponapean girls began to appear in public unclothed above the waist. Besides not being fully and neatly dressed, the Japanese did not measure up to the Germans in courteous behavior or in versatility. The technical skills of the Japanese were recognized, but they were derided by the Ponapeans because they were so highly specialized. The Japanese, furthermore, ate foods that Ponapeans considered beneath them, including snails, toads, and lizards, which are regarded as unfit for human consumption. One of the questions which never failed to bring forth laughter during my investigation of edible sea foods on Ponape was "Did the Japanese eat it?" The Japanese ate everything and anything that was digestible and not poisonous.

Until the Japanese period, the nonnative population was small except during the wars against the Ponapeans. The native population was recovering gradually from the ravages of new diseases which had caused a drop from 15,000 to 1,700 between 1835 and 1891. After the withdrawal of the naval garrison, the Japanese population was less than 150, and it grew slowly until 1930. The annual rate of growth of the Japanese population jumped from 76 in 1923–30 to 247 in 1930–33. It jumped again to 530 in 1933–38 and to 2,000 in 1938–43 when all shipping was cut off by the war. After the beginning of the Sino-Japanese war in 1937, the influx of colonists was supplemented by increasing numbers of military personnel. By 1939 the 5,905 native inhabitants were outnumbered by the Japanese, and by 1945, when all Japanese were evacuated by the American Navy, there were 14,066 Japanese on Ponape, of whom nearly 8,000 were military personnel. The combined policies of colonization and militarization saw a slowly expanding native population decline from a majority of 90 per cent to a minority of 30 per cent within fifteen years (1930–45).

Japanese colonists, Japanese enterprises, and Japanese plantations required land. In 1931 the regulations were revised to permit the sale, lease, and mortgage of native lands, which had formerly been prohibited; but at least at first such transactions were few, and carefully supervised. The problem was solved, and the greatest part of Ponape's land was alienated very neatly. It was simply announced that all unoccupied lands belonged to the Japanese administration. These lands, which had originally been owned by the district chiefs, had been made the property of the local district administrations by the Germans. One article in the deeds issued by the Germans provided that all land for which no titles had been issued belonged to the district, and that any Ponapean who wished to take part of it as his own could do so with the consent of the district chief

Japanese coconut plantation overgrown with weeds. Find the sun helmet of the USCC representative.

and the Governor. The deeds were called in by the Japanese administration, and this provision was crossed out.

Ponapeans were required to obtain licenses to farm, hunt, and fell trees in the former district lands, and most families gave up one of the important crops and abandoned shifting agriculture on the mountain slopes rather than obtain licenses. Farming was restricted completely to the farmsteads, and soil exhaustion was accelerated because fallow periods had to be reduced or abandoned. Ponapeans could acquire new farmsteads only by purchasing them from other natives. Thus a limit was set upon the amount of native-owned land, which was decreased by the sale of land to Japanese and by the government's acquisition of native farmsteads through eminent domain for airfields and naval installations.

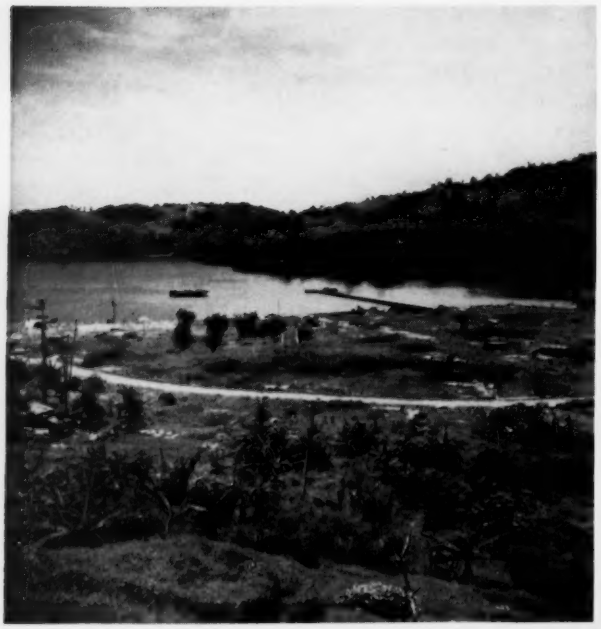
Few Ponapeans saw clearly the course which events were taking on Ponape with the compulsory teaching of Japanese, the alienation of native land, the rapidly expanding Japanese population, and the large number of half-castes born to Ponapean women. Had the trend continued, the Ponapeans as a distinct people would have soon disappeared through interbreeding and the loss of their culture and their lands. There was talk among the Japanese of completely taking over the island, and even of moving the Ponapeans to a smaller island. Though their future was not foreseen, their new subordinate position became increasingly apparent to the older Ponapeans who remembered the Germans and the early Japanese phase.

Wartime developments and excesses of the Japanese military raised doubts even in the minds of the younger Ponapeans, who had been trained in Japanese schools and who had benefited most from the period of prosperity. After Ponape was cut off by American submarines, Ponapeans were recruited for forced labor on military installations and agriculture projects to supply food for the Japanese. Women worked side by side with the men in the fields, regardless of the traditional Ponapean patterns of division of labor. Nearly all able-bodied individuals were taken from their farms, which were neglected. Some 40,000 coconut trees were cut down to build fortifications, in many cases without the payment of the small compensation that had been promised.

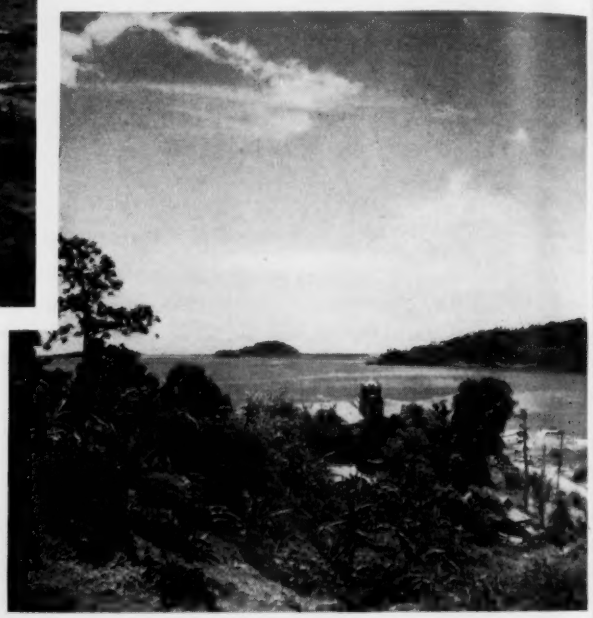
Clothing and dishes were appropriated by the military, with the result that many Ponapeans buried their good china until the war was over. Some houses were invaded, and floors, walls, and furniture torn up for firewood. All district feast houses were ordered destroyed. Ponapean girls as young as thirteen or fourteen were taken away to serve as domestic servants and, as a matter of course, as mistresses to the Japanese men. As the number of half-castes today indicates, this practice was too widespread to be dismissed lightly by the older people, who had been able to regard the Ponapean prostitutes of the whalers as a special class of women. Ponapeans had observed a strict code of morality even before the arrival of the missionaries, and this had been encouraged by the Germans.

When Ponapeans protested to the civilian authorities at what sometimes appeared to them to be wanton destruction, they were given no satisfaction; and they soon learned that complaints to the military got them nothing except beatings. One may suspect that Ponapeans have learned that charges of this kind against the Japanese can be used to win American sympathy and friendship. Nevertheless, there is less loyalty and devotion to the Japanese than one might have expected from their long period of rule and the compulsory education in Japanese. Certainly, when the Americans returned as the new rulers of Ponape, they found a situation quite different from that on Palau, where the people remember the period of Japanese administration as the "golden years" of their history.

The Americans. Since September 15, 1945, when the local Japanese garrison surrendered to the U.S.S. *Hyman,* Ponape has been ruled by the United States. The second largest island of the



Ruins of the former city of Colonia, burned out by American incendiary bombs in February 1944.



Left: Remains of the Catholic church, dynamited by the Japanese. *Right*: Temporary Catholic church constructed in native style after the American occupation.

former Japanese mandate, with a population of 5,500, Ponape was formally assigned to the United States by the United Nations on April 2, 1947, as part of the Trust Territory of the Pacific Islands. It is still too early to give a full appraisal of American policy, but it is not too soon to consider the situation encountered by Americans on their arrival, or the problems of the people of Ponape, for whom we have assumed responsibility in the name of our own security.

Although Ponape was surrendered peacefully, it bears deep scars of war. The largest town and principal harbor, Colonia, which had about 4,000 Japanese inhabitants, was burned to the ground by American incendiary bombs between February 10 and 22, 1944, and thereafter Ponape served as a routine target for almost daily practice raids by American planes based in the Marshalls. Few Ponapeans were killed or injured, however, and Ponapean property losses through American action were small compared to those through confiscation or destruction by the 8,000 Japanese military personnel stationed on the island.

When the cycle of empire had been completed and the Americans returned once again to Ponape, this time in the role of conquerors and rulers, they found a situation which was favorable from many points of view. Americans were remembered with warm feelings because of the early missionaries, and American goods were known for their superior quality. Japanese goods had disappeared from the stores after two years without shipping. The native economy had been disrupted by the Japanese program of forced labor and changes in land tenure, and by the American submarine blockade which cut off copra exports. Education had been neglected because of the war. Disillusionment if not actual hostility toward the Japanese had set in.

Although the Ponapean economy had been self-sufficient before 1827, and trade with neighboring islands had been negligible, Ponape had become dependent on the outside world for cloth, hardware, and imported goods during the period of contact. Iron knives and tools replaced those formerly made of shell and stone. Imported china was used, and new tastes for salt, sugar, tea, rice, wheat flour, canned milk, canned meat, and tobacco had been acquired which were not satisfied by local production. Nails and sheet metal were required for the Western-style cottage of locally sawn or imported wooden planks which replaced the old-style thatched house. Matches replaced the fire-plow, though during the war, when supplies were cut off, the use of the fire-plow was revived and adopted even by the Japanese. The old native forms of clothing were laughed at by the Ponapeans. Largely through the deliberate efforts of the missionaries, cotton clothing of foreign design had been universally adopted, and the techniques of weaving and making bark cloth and native sails had been lost.

During the war, as their imported dresses wore out and stocks in the Japanese stores disappeared, the women were reduced to wearing wraparounds made from mattress covers and canoe sails, the lack of which made travel by canoe difficult. In time, these, too, wore out, and many women were forced to stay on their farms, hiding in the bush if anyone approached, and going to the hospital, the store, or to church only if they could borrow the clothing from a friend who was willing to stay home. Men, after the first few had braved the ridicule that met them, resumed the use of the grass skirt, which on Ponape is a male garment. Although in other parts of the South Seas women wear grass skirts, their use was not seriously considered by Ponapean women until about a week before the Japanese surrender, the imminence of which was kept a secret from the Ponapeans. At this time the rumor went round the island that no one had any more cotton clothes, and some women started making grass skirts for their own use. The arrival of the Americans killed the rumor, but did not materially relieve the situation. Some women received piece goods in February 1946, and others made wraparounds out of the broad hems of the mosquito nets sold by the Navy, using the netting to make blouses which did not satisfy the local standards of modesty but which were better than nothing. As late as midsummer, nine months after the American occupation, there were fifty to one hundred women in one district alone who were still hiding out on their farms because they had no clothing. Only one woman, so far as is known, dared to appear in public in a grass skirt.

A rapid restoration of the prewar economic conditions, by itself, would have insured Ponapean loyalty and gratitude to the new American rulers. During the first year of occupation, however, the record was most disappointing. No copra, which provides the principal source of cash income, was purchased. The average per capita income during February, March, and April 1946 was 1.5 cents per day, and most of this was concentrated in the hands of a hundred-odd employees of Military Government. The rest of the island had only the money received in exchange for the Japanese yen, which had been called in by Military Government. Because no person could receive more than $50, regardless of the amount surrendered, more than

three fourths of the value of the yen held by Ponapeans was withheld. Military Government figures show that $27,863.94 was paid out to the residents of Ponape, representing ¥139,319.70 at the going rate of exchange of 20 cents per yen, whereas ¥626,002.60 was surrendered. By the end of April, the average amount of cash on hand, with which to replace all the imported goods that had been worn out, appropriated by the Japanese, or destroyed during the war, was $4.03 per person.

Even this money was of little value because imported goods were not available for purchase in any significant quantity until the summer of 1946. Knives for producing copra, nails for repairing and rebuilding houses, cloth for sails and clothing, hardware, and other items were not available.

If the situation was bad on Ponape, it was incomparably worse on the smaller outlying islands. A few trade goods were sold during the short visit by a screening party in February, but there was no source of income. Japanese yen were collected from Mokil and Pingelap, but because of a lack of shipping, it was impossible to arrange a return visit to distribute American dollars. Ironically, the first American visit to these two islands reduced them to barter. They remained without a medium of exchange until the chief of Mokil and some of his people traveled the ninety miles to Ponape in a twenty-foot native-made whaleboat, using mats as sails, and returned with their money and some trade goods. Their party arrived on Ponape just in time to join the Fourth of July celebration of American independence.

Despite these conditions, there was no real hunger on Ponape. Immediately after the Japanese surrender, Ponapeans had returned to their farms and resumed subsistence agriculture. Ponapeans are able to provide their own basic needs for food through farming and fishing, supplemented by gathering and hunting. Although the subsistence economy revived quickly following the Japanese surrender, the production of copra lagged sadly. A Military Government report of January 1946 stated:

> The natives who had been forced to work by the Japanese have readily accepted their new "freedom" and refuse to work on the large coconut plantations. Each native has dreams of being his own king and the plantations which now have a beautiful supply of nuts lie dormant.
>
> During the past four years the plantations, for the most part, were not cleared of heavy underbrush. The clearing of plantations will require long arduous labor,—to which work the native is apathetic. Until this bush is cleared away the plantations will produce little copra, for the nuts cannot be readily found with the facility necessary for commercial success.

Other factors, far more important than any dreams of being kings or apathy toward hard work, were involved, including the necessity of producing subsistence goods. Imported foods were not available except in meager quantities, and the primary need was to avoid starvation. Houses and canoes, which had been neglected because of the war, had to be repaired or replaced. The clearing of the coconut plantations, which had become overgrown during the period of forced labor for the Japanese, had to wait until subsistence needs had been satisfied. The "large plantations" mentioned in the report were owned by the Japanese, who had been evacuated, and by Oliver Nanipei, the wealthiest Ponapean. With the $50 he received in return for his Japanese yen, Oliver Nanipei found it impossible to find laborers to care for his 87,000 bearing trees.

The production of copra was also delayed by doubts about the American program of copra buying, despite numerous assurances that all that could be produced would be purchased. Ponapeans were urged to resume production when there were no knives with which to produce it, when no agency existed to purchase it, when there were no warehouses in which it could be stored, and when inter- and intraisland shipping was inadequate to export it. At the same time there were no imported goods to be purchased with money received for copra.

A part of the delay may also be attributed to speeches by one of the first officers to arrive, announcing that the Ponapeans had been "liberated"

Lumber from vacated Japanese buildings moves along an abandoned railway to rebuild homes.

by the Americans, and were now free to do as they wished. This announcement was given many interpretations. Having resumed subsistence farming, some interpreted it as a blessing upon a return to feasting, kava drinking, and relaxation after the period of forced labor, which had been widely resented. Others interpreted it as meaning they had no more obligations to their own chiefs, and the question of the ultimate position of Ponapean chiefs was unnecessarily aggravated. Later they were to learn that these ringing phrases had not meant all the things they had understood. Those who had expected to move into Colonia and rebuild the city there were told that they could not do so. Those who had expected to return to the farms appropriated from them by the Japanese, or to work the Japanese coconut plantations, were given only temporary rights to part of this land, with no assurance of permanent tenure. They were told that, as former Japanese property, this land now belonged to the American government and that final disposal had to await the conclusion of peace negotiations with Japan. During the first year of American administration, shifting mountain farming and the growing of an important crop in the freshwater marshes, which had been abandoned because of Japanese land restrictions, had not yet been resumed. Although a large part of the island was uninhabited, there were still some 150 landless families on Ponape.

Since most of the island of Ponape had been expropriated by the Japanese by the simple declaration that uninhabited district lands belonged to the Japanese administration, it would seem that this land could with equal ease be returned to the Ponapeans in the same way. Whatever legal difficulties may be involved, a sound American policy for Ponape must be founded on an adequate guarantee of Ponapean land tenure, with the abolition of Japanese modifications of land laws since 1930.

America must also provide a market for copra at prices sufficient to purchase the imported goods upon which Ponapeans have become dependent through the acquisition of new tastes, the development of new needs, and the disappearance of important native handicrafts under competition with manufactured goods from the outside world. Before the war the two Belgian families on Ponape found that it was no longer necessary to order supplies from abroad, since everything they needed could be purchased locally; and even before Pearl Harbor, most Ponapeans had worn better clothes, lived in better houses, and eaten better food than the Okinawan immigrants. The picturesque era of the grass skirt and the grass shack had ended.

Having assumed responsibility for Ponape in the name of our own safety, we cannot honorably ask the Ponapeans to accept a standard of living lower than that which they enjoyed under the Japanese. If increased costs of shipping or the higher price of American goods makes subsidies necessary, the cost will not be great because the population of Ponape and other islands of the Trust Territory is small. If these islands are essential to our national defense, this cost is a legitimate military expense for the maintenance of a string of island fortresses.

American officers, on the whole, were well liked and respected by the people of Ponape, but the enlisted men fell short of the standards in terms of which Ponapeans judge their previous rulers and themselves. Their versatility in practical skills was not questioned, but they were criticized for appearing at work and in the movies without shirts, and for drunkenness and obscenities in the presence of Ponapean women. The problems of the commanding officers were not decreased by the assignment of troublemakers and enlisted men who had broken regulations elsewhere for duty on Ponape.

The original occupying force was kept busy establishing a base of operations, disposing of Japanese ammunition, collecting Japanese yen, and evacuating the Japanese military and civilian personnel. They had little time for concern with native problems. When these tasks were completed the base was reduced to a size which, because of the type of personnel and the inadequate shipping facilities, had all it could do to maintain itself and its own installations. Japanese equipment rusted and disappeared, and the jungle seemed to be closing in. Almost the entire effort had to be devoted to keeping generators, reefers, vehicles, telephones, the radio station, and the camp water supply operating as well as possible. By comparison with the Japanese garrison, the force of forty-odd Americans was totally inadequate in numbers, but by comparison with what five or six German officials had accomplished on Ponape, there should have been much more to show for the first year of American rule.

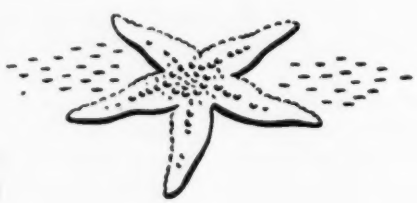
It was not until ten months had passed that personnel qualified to tackle the functions of Military Government arrived. Schools had been set up, on paper, almost immediately after the Japanese surrender. From two to four school teachers were appointed in each of the five districts, but until April, when they were put on a salary of $5.00 a month, they worked without pay. Classes were held in former Japanese schools or stores, in many cases without desks, maps, textbooks, paper, or pencils. Though only a minimum of attention could be devoted to native administration, a sound foundation

for the future was laid and an important step forward was taken in the initiation of a series of monthly meetings of the chiefs of the five independent political districts.

These meetings were left almost completely to the Ponapeans, who could freely discuss questions pertaining to the island as a whole, reporting on their discussions and conclusions later to the Military Government officer. Among the questions considered were taxation, salaries of district officials, the maintenance of roads, the production of copra and other commodities, import requirements, the development of schools, the standardization of Ponapean spelling, and the codification and unification of customary law. No such attempt to unite the districts politically was made by the Spaniards, the Germans, nor the Japanese, and the Ponapeans have been quick to comment on this difference in policy between the Americans and their preceding rulers. The brightest spot in the American record has been the Navy hospital and dispensary, which gave two to three thousand treatments a month to Ponapeans without charge. With the small populations that are found in Micronesia, medical services on this scale should make it possible virtually to wipe out yaws, gonorrhea, and other diseases.

Opening coconut for drinking.

Aside from the Navy hospital and honorable intentions, Americans had little to be proud of during the first year of occupation of Ponape. Ponapeans, however, have found something to be grateful for in the monthly interdistrict meetings and in the fact that they have been able to return to their own farms. In the face of shortages which would have caused violent protests in any American community, Ponapeans have withheld final judgment of their new rulers. Realizing something of the difficulties under which Military Government was operating, they have been content to wait with exceptional patience and tolerance to see what the future has in store for them.



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Travel and Its Meaning

ALAN GREGG

Dr. Gregg (M.D., Harvard Medical School, 1916) has been associated with the Rockefeller Foundation since 1919 and director of its Division of Medical Sciences since 1930. As a member of the Foundation's field staff, he was stationed in Brazil for three years. His article is based on his vice-presidential address (Section N, December 29, 1949, New York AAAS Meeting).

TRAVEL and its meaning for scientists is perhaps the only subject on which I could speak from long experience and with a reasonable hope that it would possess some general interest for my audience. For another reason I am inclined to talk about travel. I have begun to wonder what will prove to be the distinctive American contribution to the long history—still unfolding—of world scholarship. Will it be in our administration of libraries? Will it be in showing the advantages of teamwork in research and teaching? Will it be in the wider extension of higher education to a larger fraction of the population than ever before? Or might it be the adventurous but well-justified insistence that travel is essential to the very best scholarship; that travel is the indispensable ingredient of education in a world where now technology makes travel easy and the only corrective to perfervid and disastrous nationalism? This article will be something of an essay on travel as I have seen it, with a few hints as to how travel may be done sensibly and seriously, and the brief for an argument in favor of regarding travel and its results more carefully than they are regarded today.

At the root of the nature of travel lie two simple but cogent facts: that contrast always alerts the attention, and comparison enriches the resources, of a healthy mind. As biologists we have all observed that the simplest kind of locomotion inescapably brings the organism into a new and usually a changed environment. By so much more does travel, the apotheosis of locomotion, assure us of contrast. But travel can bring more than change. The sensation of contrast provides the basis for a still more intricate and rewarding operation of the mind—namely, comparison and its offspring, analysis, and, in resynthesis, an amazing sense of freedom.

From the very beginning travel played an extraordinarily important role in the nature as well as the spread of the early European universities. Before Gutenberg developed the art of printing about five hundred years ago, no cheap or uniform method existed for spreading or getting ideas except the spoken word. Consequently travel, for at least the first three hundred years of Western European universities, was almost essential if facts and ideas were to be spread to, or exchanged between, any considerable number of scholars. In gradual increase the number of printed books certainly reduced the apparent need for travel. The development of postal service within and between many countries in the nineteenth century further weakened the case for travel. Could not books and the penny post keep every teacher abreast of what was going on everywhere in what used to be called the civilized world? Well . . . Yes; and, on second thought, a wistful No. For there still seemed to be something about travel that could not be derived from the printed word or the exchange of letters. But travel was expensive. It was arduous and precarious. It was more dangerous than it is today. And until the traveling teacher had returned, someone must be found to take his place. Then came the professional journals which grew, I should suppose,

from the printed transactions of the learned societies. These professional journals gave further solace and reassurance to him who found the expense of travel difficult, and the effort onerous, and the necessary arrangements inconvenient. So it has come about that a substitute has engulfed the original, the moon has eclipsed the sun, and easy reading has hidden from view the excellences of travel. The highly edited written word has become the chief article of the scholar's diet, as polished rice became the meretricious staple of the Oriental diet. And travel, which in early days was a part of the coarse fare of every scholar, today deserves to have attention called to its irreplaceable importance, as though it contained a vitamin that has been ignored. In short, scholarship can, and I believe does, suffer from the analogue of beriberi—which is a bookish provincialism.

If the printer and the postman can sing us to sleep, or at least into complacent stupor, we should in all honesty admit that two other means of communication no less seductive have now begun to furnish additional deceptive counterfeits for first-hand experience. I refer to the movies and the radio. I have often refreshed my skepticism as to all representations of reality by the memory of the skepticism of a simple but sagacious Brazilian *caboclo* in 1920. In the eager hope of convincing him that intestinal parasites existed whose eggs could not be seen, I arranged a microscopic preparation teeming with the eggs and young forms of strongyloids. His astonished exclamations encouraged me to think I had clinched the argument, so I said, using the vernacular expression, "Now don't you believe that there are tiny snakes in your belly that suck your blood?" The reply was "No, Senhor, I do not believe that because I see lions and tigers in the cinema, but they are not there!" Let us beware, as he did, of the subtle unrealities of every form of substitution of reality.

I

The case for travel could be pressed on still other grounds. If it be true that we forego travel partly because books, journals, letters, and in increasing measure movies and the radio seem to make it unnecessary, then it is even more worth while for us to realize that nowhere in the world and never in history has so large a mass of human beings as our 150,000,000 shared so nearly homogeneous a source of news, opinion, values, and language. Is there any reason why provincialism, indeed almost parochialism, cannot exist on a continental scale? Will anything but travel correct the obtuse certainties, the irritable rigidities, and the senseless but complacent superiorities of the provincial mind? Each day the Associated Press and the United Press provide us Americans with most of our news. Four of our weeklies have a total circulation reported as over 14,000,000 and certainly three to four times that number of readers. The weeklies take part obviously enough not only in conveying news but also in forming the interpretation of events, and so the opinions of millions of people. Only the one who has read the *Reader's Digest* the day it appears can arouse surprise as well as appreciation of its humorous stories when he retails them to a random dozen of his friends. Having a circulation of more than 8,500,000, its anecdotes soon lose their novelty. The same movies are seen and heard by millions within two months of their release. The *Film Daily Yearbook* estimates the weekly attendance at moving-picture houses in the United States as 90,000,000. And daily listeners to messages conveyed over the air are calculated at 100,000,000—and the repeated messages in hundreds of millions of "listener impressions." Indeed, the very task of estimating the number of persons that a single idea reaches on the air, be it true, half-true, or false, has become a business.

Furthermore, the enormous internal market in this country offers to assembly-line and standardized machine manufacture a fantastic demand and reward. The result is an astonishing uniformity of materials and machines familiar to tens of millions, all over the country. In a store window in Colorado last month I saw a sign that read "Antiques and Unusuals." I take that to be indirect evidence of the extraordinary uniformity of human experiences in this country—and uniformity of experience is the raw material out of which provincialism grows.

The real danger in the extraordinary homogeneity in this country is not merely that this uniformity escapes our attention so easily but that an opinion by the mere weight of the numbers accepting it may be taken for that reason alone to be indisputably true. That is the essence of provincialism, and the danger of it and the ridiculousness of it.

Add to this Gadarene tendency two further considerations and you have a considerable array of arguments for travel—not mere physical travel but the act of deliberately going somewhere where you will be in the minority, where things are different, where those easy assumptions, accepted perhaps by everyone you know in America, will be challenged or examined more closely than you ever examined them yourself when you took them on. I would suggest that before we smile too readily at the personal vanity of the monarchs of old who so notori-

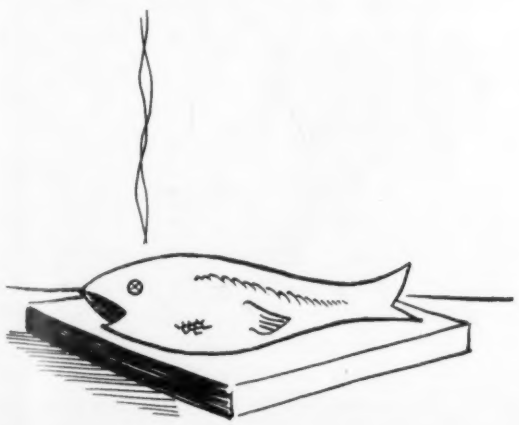
ously fell for flattery, we might consider for a moment the possibility that Demos, who rules in a democracy, may also enjoy superlative compliments beyond the point where hearing praise is good for him. Our increasingly numerous foreign visitors may be completely honest in their praise of America. But can we expect them also to warn us of vanity or complacency—and could we bear it if they were to be so kind?

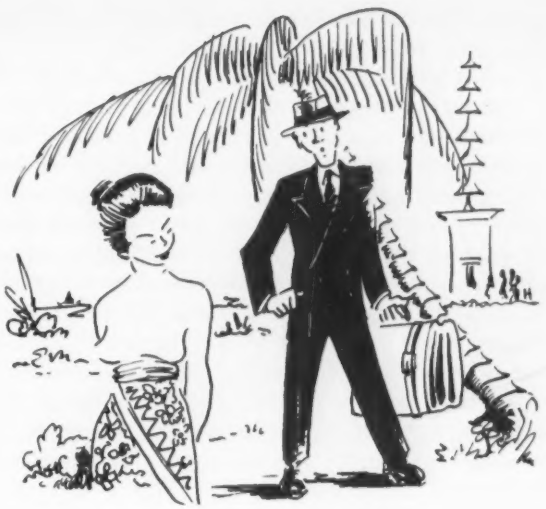
II

Having stated some general arguments for travel, I pass on to such questions as What kinds of travel are there? In what decades of life does travel mean much to us? What are some useful techniques for the traveling scientist or scholar? and What are the results of travel and the best attitude to take toward it?

Visits to a laboratory or an institution vary in character according to the amount of time to be spent there. Though there are certainly intermediate periods that accomplish results that are in effect gradations and subvarieties, in the general spectrum of visiting I would offer for your consideration three rather arbitrarily defined types.

The first is the visit that lasts anywhere from a day to a week. Such a short visit is of little value to the novice, though most beginners naïvely think of travel in just such terms. We should realize more clearly than we do that short visits, like short speeches, require more preparation than long ones. You ought to know before you visit him your host's interests. It is wonderfully smart to come to him fresh from reading his books or papers—or even one of them. At least you should know his past performance and have precise ideas of what you want to see or to ask. The visit will then stand a fair chance of being welcome and relished by both sides. Otherwise your host—if he be worth visiting—can be justified in being reluctant to put himself





out for an apparently aimless and perhaps inconsiderate stranger. And as for the length of the visit, we can on general principles try to remember the pithy Spanish saying that there are two things that stink after three days—one is fish and the other is guests.

Between the visit of a few days and a sojourn of nine months or a year there are a few intermediate periods where, for example, learning some special method or technique is the purpose. But such periods are too short usually for absorption of unexpected experiences and always too short to fit the stranger into any activity that involves putting responsibility on him. Most of our foreign friends say that the spirit of teamwork in American scientists is the most valuable impression they have received. Obviously teamwork cannot be learned or fully understood without participation over a reasonably long period, longer than a month or two.

For thoroughgoing comprehension, a three-year visit offers much that cannot be obtained in a single academic year. A new language can be learned to a really useful degree, and the underlying assumption and values of the new culture begin to be clear to the visitor who stays three years. Indeed, with anything more than a year's visit some very different factors may enter into one's estimate of the results of travel—for example, the dangers of falling in love, or of offers of permanent employment, or of being forgotten or bypassed by the people at home while you are away so long. Conventions, international congresses, traveling scholarships or fellowships, exchange professorships, or visits lasting three years—each type produces its principal result as an interaction of the maturity of the traveler and the length of his exposure to what is new. The best preparatory ex-

perience for all subsequent traveling is a three-year immersion in a culture not your own. This long exposure begins with vivid, simple, uncontradicted, categorical impressions, or even (God save us all!) conclusions. But with the passage of time you find that there was more than met the eye in your first impressions, and you begin to qualify them and often to find that you totally misunderstood their meaning at the outset. That is the illuminating aspect of a long stay in a foreign land: the capacity to suspend judgment, and doubt hasty interpretations.

Experience in one country makes the next visit to another country not only more interesting and valuable, but you become a livelier observer and a shrewder interpreter of what is to be seen and heard. As I have watched them, the most intelligent foreign Fellows with a year to spend do not begin their fellowship term with numerous short visits. They settle down in one place for eight or nine months, learn the new environment fairly well, and thus prepare the pegs on which they can safely hang the numerous impressions of later short visits.

The maturity of the traveler, and particularly his capacity for making comparisons and reflection, determine what he will get out of his visits. Although maturity does not depend exclusively on age, it is closely related to it. Now I do not think that a young American of today can be said to have the best liberal education possible until he has passed a year in some country and culture not his own. I doubt, however, if a year abroad pays as rich dividends to a student under twenty-two or -three as it will in his middle or late twenties. The best results I have seen have attended the travel of a graduate student who knows what he wants and that he will have a paid and dependable position in his own country at the termination of his study abroad. Such certainty and clarity of outlook help him to decide what will be of maximum benefit to him. At the same time his energies are freed from worry or uncertainty, and he can devote himself to the tasks in hand.

No categorical answer can be given to the question of taking the family along. In general, the longer the stay the better the case for the traveler to take his wife and children with him, even though complications and difficulties are more likely to arise. I once asked three German professors how they had fared in the United States. I was planning a similar trip for two other German professors. Going over the separate items of travel, I asked, "And how did you get along in the Pullman cars?" The reply was, "Yah! Ve haf enchoyed de Bullman cars very much, but our wives haf gomblained of de upper berths." Opinion as to whether scholars will do well to take their wives with them reminds me of Oscar Wilde's observation that all criticism is a form of autobiography: those of us whose wives belong in the column of assets are likely to favor others' taking their wives along.

The best time for Europeans to visit America runs from late September to about the middle of May. Perhaps the English visitors who suffer from the heat in our trains, hotels, and meeting rooms should be told to ask for rooms in the lower stories of our hotels where opening the window will bring cool air in and not, as at the top of high buildings, merely let hot air out. There is no advice that can be given to Europeans who plan to come to America in July and August, unless it is the simple word *"Don't."* Visitors to Europe will find that in late July, August, September, and often the best part of October it is rare to find laboratories and teaching in full swing.

In point of the technique of making visits, I could offer rather specific suggestions. If you are alone, you are a visitor. If there are two of you, you are a Commission, and if three or more, you are an Invasion. If you have to have an interpreter, remember that he has in his power the success or failure of your entire effort. Choose him with the greatest circumspection. Write to your prospective host months or at least weeks ahead telling him what day you will arrive in town and that you will telephone his office to find out whether and when it may be convenient for him to see you. Then don't fail to keep to your schedule. Take a taxi to his office, with an ample allowance for the possibility that the taxi driver will never have heard of

the laboratory and will land you there inexcusably late. You can walk back and halve the expense of getting there on time. If it is a junior staff member you really wish to see, don't omit the courteous formality of calling on his chief first: things of this kind in Europe are commonly done beginning at the top, and you can prejudice the status of a young assistant if you ignore, or let yourself seem to ignore, the local proprieties. Since the food in European restaurants and hotels is now often better and less monotonous than that in private houses, an invitation to your host to be your guest for dinner at your hotel is seldom amiss. It is a friendly attempt to make a prompt return for the time he is giving you. Keeping notes on the names, addresses, and the statements of those you have seen is an onerous but indispensable part of effective travel. Many is the night at 12:15 or 1:00 A.M. that I have dreaded the task of getting down a record of a crowded day before going to bed. At least a fifth or sixth of the traveler's time may wisely be taken in keeping a diary or adequate notes on whom he has seen and what and where. But without notes recorded promptly many a visit has failed to yield what it might have given to the traveler. In short, though travel has the flavor and appearance of mere pleasure and freedom, there are many times when it must be demanding and exhausting.

We Americans often put an unintentionally heavy load upon our foreign visitors who are not prepared for schedules in which our hospitality is pushed to the point of their bewildered but only faintly protesting exhaustion. Only those who have experienced such exhaustion may be expected to show mercy to others. The best hosts, in short, are almost always those who have traveled—another argument for travel. Actual travel thus is the best preparation for vicarious travel, which is being a good host to other travelers. It teaches the secrets of being a good host, not an exhausting one.

III

The main and the final points I wish to make concern the results of travel. The simplest category of results consists of acquiring techniques, methods, gadgets, and machines that can be copied or purchased and used on returning home, without adaptation or change. Of quite a different order is another dividend from investing time and money in travel: getting to know one's colleagues abroad or in other parts of this continent. This usually enables us to form a far sounder opinion of the significance of what they do and write. Here discoveries of new acquaintances are possible, as well as evaluations of persons whose names are already familiar. Almost no one knows all the good men in his field. Such personal contacts often lead on to correspondence, exchange of junior personnel, collaboration at some later date, and even lasting friendships that transcend as well as enrich scientific work. Another result: not infrequently a scientist through personal contacts while traveling finds heartening confirmation of his private convictions and a heightening of enthusiasms that have all too often been suffering from his living in his own university in a misunderstood minority of one. Travel gives many a specialist what E. A. Ross used to call "the we feeling"—a sense of comradeship that sustains him in his isolation or loneliness. None of these results can be so safely expected from mere reading.

A still more important result is that the traveler is likely to find new concepts, ideas completely novel, or interpretations and values he had never thought of before. We must constantly remind ourselves that not everything worth while gets into print. Not every gifted baby that is born survives: not every idea or hypothesis that might be worth knowing gets published. Can any of us think of any first-rate scientist he has known whose every useful speculation or observation was published? I plead for a clearer recognition of the value of personal contacts between scholars. And I have to plead because the cheapness, the volume, and the ease of printing, of photography, of the cinema (and soon the radio) are ever so gently cheating us of an elusive but essential factor in the growth of science and the decorum of the scientist's life.

Like Sunday itself, the sabbatical year seems to be going through a process of attrition. Are many university professors nowadays reprimanded by anyone but their wives for not taking regularly a full sabbatical year? Airplane pilots sign contracts that forbid them to exceed a stipulated maximum of hours of flying per month. What of those who pilot the next generation? Do we not need the alertness that comes from travel, from a change of scene, of tempo, and of ideas? Without adequate circulation and exchange, necrosis sets in at the place that is furthest from the periphery—namely, the center. That is the penalty, or at least the risk, of staying in a great center of anything—learning included. I have seen some great centers or, better, some great tumors of learning with characteristic necrosis for lack of interchange and circulation.

Still more intangible than techniques, new acquaintances, and new ideas, one further result of travel can be the discovery of yourself. If you got your B.S. from Balaclava University and then an A.M. at Balaclava and then a Ph.D. from the same

institution, how can you ever know what is you and what is only Balaclava? In a rather profound sense the main value of travel lies not in where you go but in leaving where you have been. Growing up is not a merely additive process. It involves getting rid of the shaggy excrescences that were put upon you by earlier indoctrination and your own unchallenged acceptance of a long-reiterated environment. Travel can cut, and reflection can tie, the umbilical cord of many a young man. Go to a new place. Have your former gods challenged or, even worse, ignored. If they were really good, they will survive. If not, they shouldn't. Re-examine your axioms. Find out the evidence for your assumptions and you will with good luck find yourself and begin to set the true value upon the environment from which you came. I never tire of Sir Oliver Lodge's way of saying this: "The last thing in the world that a deep-sea fish could discover is salt water."

It is by no mere chance that mountaineers and seafaring peoples have been those most inclined to travel. From babyhood they faced horizons that could be passed by audacity and activity. And experience so often justified their assumption that beyond the usual horizon lies something of interest and of value. If Americans can bring back into world scholarship a lively recognition of the inexhaustible benefits of travel, then we could rightly claim that we had made an appropriate contribution to world culture. Travel is already our heritage. We are not afraid of distance. We are even beginning to be sophisticated about the elusiveness of mere words—thanks to our growing distrust of propaganda and commercial rhetoric. I would like to see universities spend as much money on the travel of their teachers as upon their library budgets—and more. This is no slur upon libraries. Indeed, we don't teach our students enough about using libraries. But there is just no adequate substitute for travel—not in the world of the next half century. It is the besetting sin of scholars to resign themselves to substitutes for firsthand experience.

In the early days of the Mayo Clinic it was the custom that the staff members devote three weeks in any year to visiting other hospitals and laboratories and that they report on return to their colleagues in the clinic what they had seen. One other stipulation indicates the sagacity of the brothers Mayo: those three weeks of scouting were not regarded as a substitute for vacation. The scouting was to be done when the traveler was prepared for the hard work ahead. Most people think of travel as mere pleasure. Maybe that is why we are so reluctant to realize that serious travel is hard work. The Mayos knew that the duty to observe and record accurately and compare reflectively during and after visits demands the best that the visitor can give. I have long enjoyed recalling the visit made to the Massachusetts General Hospital by Dr. Henry S. Plummer, of the Mayo Clinic, in 1916, when I was a house officer at M.G.H. His conduct was so refreshingly modest and unassuming and his questions so direct and well chosen that we concluded the Mayo Clinic must be pretty intelligent to send someone to learn from us! Whether this was an exquisite sample of complacent vanity, or whether it suggests that visitors, next to imitation, are the sincerest form of flattery, or whether it indicates the disarming power of modesty, I do not have time to debate, for I have come to the end of this essay on travel.

But I do commend travel to your most earnest reflection, raising the question of whether it is as widely and as energetically practiced as it used to be and now deserves to be, pointing out its principal characteristics and its numerous inimitable consequences. To the American scientists of today and tomorrow I would commend this gentle but obdurate opinion: "I have often heard that it is wise to go and learn but I have never heard that it is wise to stay and teach." In that direction surely the horizon of American scholarship beckons.

Salt Production

WENDELL G. WILCOX

The author, who has a Ph.D. in physical chemistry and chemical engineering from the University of Wisconsin, has been engaged in industrial work for more than thirty-eight years and was for many years—until his retirement June 30, 1948—vice president of the Morton Salt Company. Dr. Wilcox is at present managing director of the Salt Producers Association (Detroit).

SALT is absolutely essential to the life processes of man, of domestic animals, and, we believe, of all warm-blooded animals. Presumably early man got his salt from dried-up pools of sea water left by high tide, from salt licks, or from desert playas (dried-up lakes). No doubt his first production of dry salt, which he could carry with him, had to wait for the time when he learned to fabricate from clay a watertight, fireproof bowl to hold brine or sea water that he could boil to dryness. Tradition has it that the ancient caravan trails of the Sahara and of the Arabian Desert were established for traffic in salt. We know that the ancient Phoenicians traded in salt; until comparatively recently, the interior African tribes sent some of their young men to the coastal tribes where, after a period of servitude, they were permitted to take back salt to their own tribes. These Negroes were sold into temporary slavery for salt. Our word "salary" is derived from the fact that salt was part of the Roman soldier's ration. In medieval times it served a social purpose; those seated between the host and the bowl of salt at the banquet table were said to be "above the salt" —they were the socially elite; those on the other side of the salt bowl were "below the salt." The scarcity of salt in Roman times is indicated by the fact that shipments of salt produced in Ostia, Italy, were moved over the Via Salaris (the salt road) to the city of Rome under armed guard. The English place names such as Greenwich, Sandwich, Ipswich, etc. refer to the sites of salt manufacture or trade, for the word *wich* in Anglo-Saxon has that meaning. In our own country the meaning of place names such as French Lick, Deer Lick, Blue Lick, Booneslick, etc. is obvious.

But salt is fully as vital to modern industry and agriculture as it is to life. As the cheapest source of sodium and chlorine, it is the basic raw material of the chlorine and alkali industries and of the innumerable chemical processes which involve the use of chlorine, metallic sodium, or sodium compounds. The great commercial salt deposits of the United States are found in New York, Ohio, Michigan, Kansas, Louisiana, and Texas. Fortunately for us these deposits are not only inexhaustible, but they are located close to our great industrial centers and to our chief food-producing areas as well. The state geologist of New York estimates that, in this state alone, there are nine cubic miles of salt. The state geologist of Michigan estimates that the salt deposits of his state would serve the needs of this country for five million years at present rate of consumption.

In addition to these vast deposits of solid salt, mineralogically called halite, there are in the Ohio Valley–Kanawha area and in the Saginaw Valley of Michigan underground brines from which are produced salt, calcium and magnesium chlorides, and bromine. Like the solid salt deposits, these brines were formed during past geological ages; they are termed "fossil" brines. West of the states of Kansas, Oklahoma, and Texas, there are no commercially exploitable halite deposits other than some dried-up desert lakes, and these are commercially unimportant. Salt production in this western area relies upon the solar evaporation of the waters of the Great Salt Lake in Utah and of sea water in the state of California.

Salt is produced (*a*) by dry mining, (*b*) by the use of or the evaporation of saturated brine when salt is mined hydraulically, and (*c*) by solar evaporation of sea water.

The thickness, position, and characteristics of the salt strata of New York state, Michigan, and Kansas permit dry mining. By sinking shafts to salt deposits at depths of 1,000–2,000 feet and working a stratum of sufficient thickness to provide ample headroom, salt is mined by the "room-and-pillar" method (Figs. 1–5). Long parallel galleries are excavated, and enough salt is left in place between them to support the roof of the mine. Salt is an excellent structural material, so there is no problem of roof support, nor is there any problem with

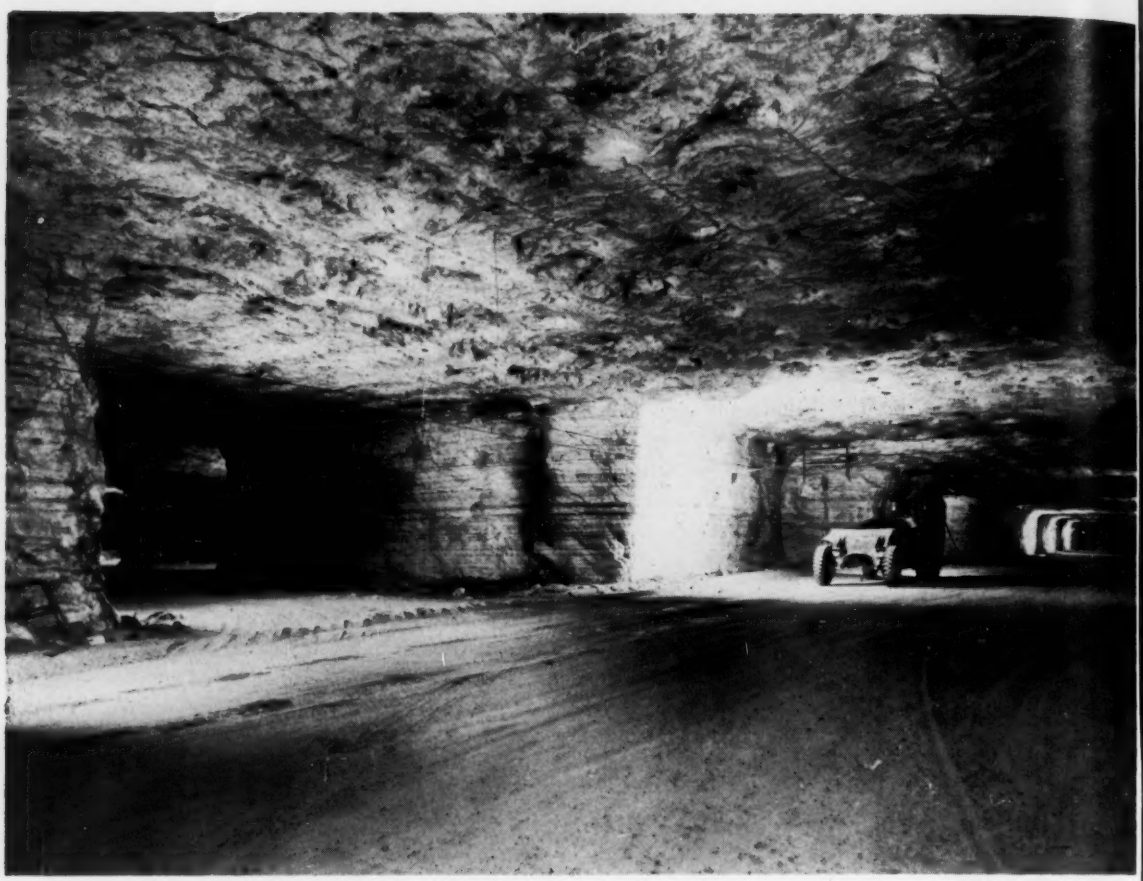


FIG. 1. International Salt Company's Detroit Rock Salt Mine.

gas or dust. These mines are dry and clean, and they have an even, comfortable temperature, winter and summer. The working face, which may be 20–30 feet high in Northern mines, is undercut, holes are drilled in the top, and the salt is blasted down. Picked up by power shovels and transported to the foot of the shaft, the larger pieces are crushed and the salt is hoisted to the surface, where it is again crushed and screened to various sizes for shipment.

The remarkable salt deposits of Louisiana and Texas are known as domes. These are extraordinary structures in that they consist of great columns of salt, more or less cylindrical in shape, rising, we believe, from a salt stratum two miles below the surface, nearly to the surface. Under the tremendous pressures developed on this deep-lying stratum of salt by two miles of overlying rock, the salt becomes plastic and slowly flows. It is believed that, where there was some weakness in the overlying rock structure, the salt slowly forced its way toward the surface and that the pressure was partially relieved by the development of this gigantic column of salt. The intrusion of salt greatly disturbed the overlying formations; hence around the perimeter of some domes deformation of the rock structures formed suitable retention areas for oil and gas, and likewise localized accumulations of native sulphur. Salt is mined at present on six domes in the Louisiana–Texas area. Sinking shafts to about a thousand feet in the dome and mining by the room-and-pillar method, operators have opened up rooms that are 70–90 feet high, the roof being supported by columns that are approximately 70×70 feet (Fig. 6).

In many of these Southern domes the salt is snow white and amazingly pure (99 per cent NaCl) for a natural deposit, whereas the product of the Northern mines, by reason of the presence of small amounts of shale, gypsum, anhydrite, etc., is light to dark gray in color and cannot be used for edible purposes. The production of a pure edible salt requires a different technique in mining and in the processing of the salt after it is mined. Wells similar to oil wells are driven down to the deposit; pure water is sent down through one or more wells; the salt dissolves, forming a brine that is close to saturation. This brine is brought up

FIG. 2. Undercutting the salt.

through other wells by a combination of pressure and lift, the lift being supplied by deep well pumps or by compressed air. Such a brine, reflecting the impurities in the natural deposit, will contain ferrous iron, small amounts of the chlorides of calcium and magnesium, calcium sulphate, and hydrogen sulphide. Impurities like shale are left behind. This is a typical hydraulic mining operation.

It is interesting to note that Herman Frasch, then chemist of the old Standard Oil Company, was also made chemist to the old Union Salt Company in Cleveland when the latter was bought by the Rockefellers in the early nineties. There he saw salt mined hydraulically, and this gave him the idea of the Frasch Process, whereby the sulphur associated with some of the Southern salt domes is similarly recovered by the use of superheated water.

According to the report of the Bureau of Mines for the year 1948, a total of 11,535,000 tons of salt was converted to brine by this method. Of this amount, 9,350,000 tons were used by chlorine and alkali plants situated directly over or within pipe-line distance of salt deposits. After purification the brine is used by these plants as their basic raw material. Salt manufacturers, who purify the brine and manufacture pure, edible salt from it by evaporative processes, produced and used 2,186,000 tons. Eighty per cent of the salt obtained by the evaporative process in 1948, or 1,724,000 tons, was produced by multiple-effect vacuum pan evaporation. These vacuum pans are usually run in quads but sometimes merely as triples or doubles. In large plants, the vacuum pans will be 16–22 feet in diameter and 60–70 feet high (Fig. 7). The first vacuum pan (called the "first effect") is heated by low-pressure exhaust steam and is under a slight vacuum. The vapor from the boiling brine in the first effect is passed into the heating belt of the second effect; as the second effect is under higher vacuum than the first, and therefore boiling at a lower temperature, the vapor from the boiling brine of the first effect will boil the brine in the second effect. Similarly, the vapor from the boiling brine of the second effect is used to heat the brine in the third effect, and that of the third effect is used to boil the fourth. The fourth, or final, effect is under such high vacuum that the brine boils at a temperature as low as 120° F. Thermal efficiency is high, and in the well-designed and well-managed plant heat balance is maintained. That means the prime movers—namely, the turbine of the turbo-generator set, the steam engines driving the air compressors, the brine, water, vacuum pumps, etc.—produce just enough exhaust steam for the evaporators. In such a plant electric power, compressed air, and such operations as pumping and the like are virtually by-products of the salt-making process. The salt produced by vacuum pan evaporation is commonly termed granulated salt, because it crystallizes in small cubes similar to granulated sugar.

In the food-processing industry large tonnages of salt are used, but the variations in processing compel each industry to have a salt which in grain size, purity, and speed of dissolving fits into its processing. To meet such a demand and to produce salt of these various characteristics, different processes of manufacture must be employed. Generally speaking, salt for this purpose is produced in open steel pans approximately 12–18 feet wide, 2 feet deep, and 100–120 feet long (Fig. 8). Steam coils are placed in the bottom of the pans, which are filled with a purified saturated brine. There is no agitation or forced circulation. Evaporation can occur only at the surface. The cubical crystal forms at the surface and, attaching itself to others, forms a platelike or flakelike aggregate that builds up until it overcomes surface tension and drops to the bottom. If the first crystals formed sink only gradually, a hopper-shaped crystal will be formed. Removed periodically, dried, and screened to size, the variety of products obtained ranges from crystals almost as fine as talcum powder (used by flour mixers for pancake flour, cake flour, and the like) to somewhat larger crystals used by creameries (where rate of solubility is most important) and to still larger crystals used by the cheese- and pretzel-makers. Many of these uses require a high order of purity. For example, calcium sulphate hardens peas, so that salt for the pea-canner must be free from calcium compounds. The alkaline earths im-

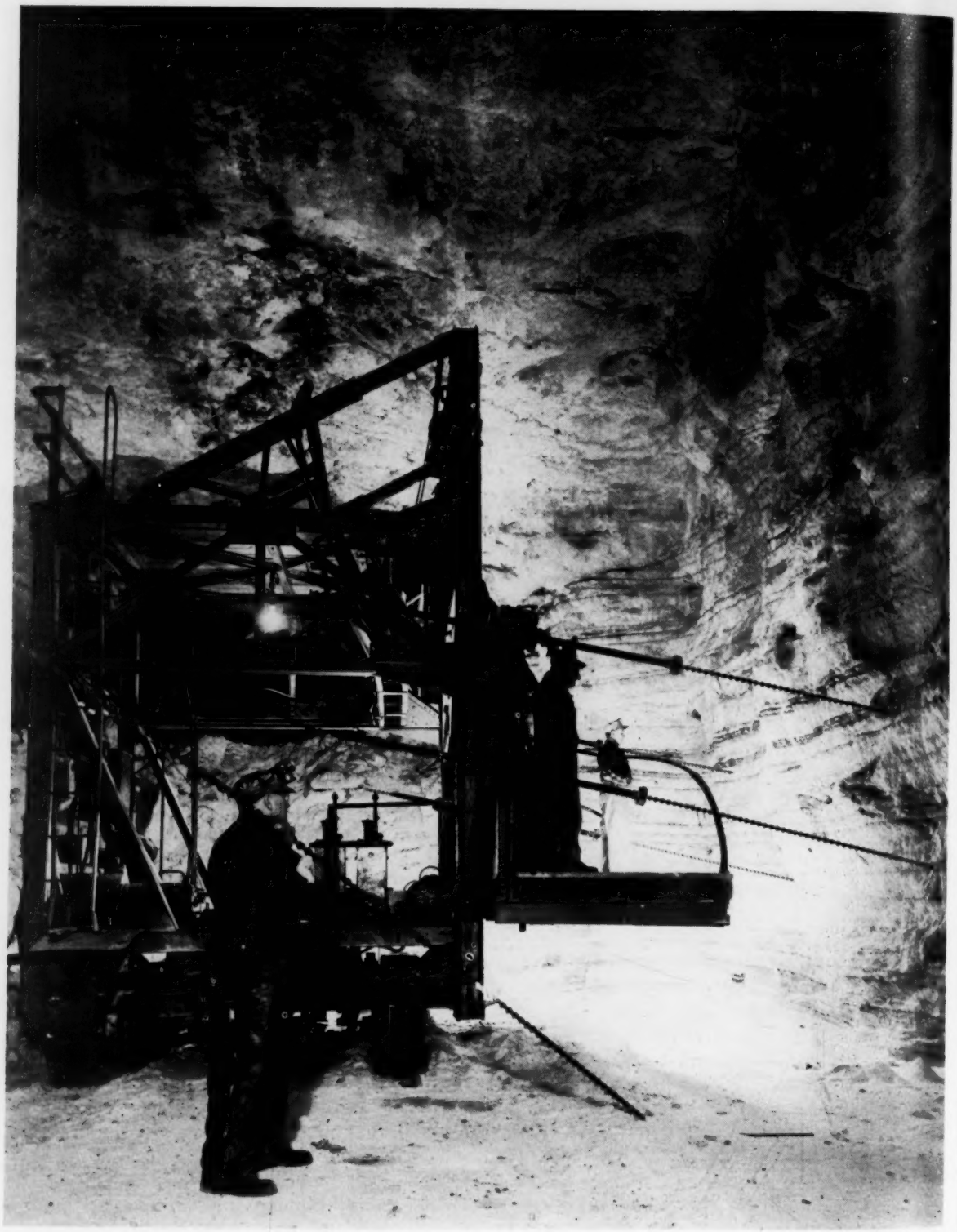


FIG. 3. Drilling.

part a bitter taste to butter, so the butter manufacturer requires a salt with a purity of 99.8 per cent or higher. Salt with a purity of 99.9 per cent is produced commercially by the thousands of tons. In small tonnages, some salt is being produced with a purity of 99.99 per cent.

A large evaporative salt plant requires a substantial acreage of ground on which to put down twelve to twenty wells, costing from $40,000 to $70,000 apiece. The investment in these wells, together with the extensive piping needed to convey pure water to some and bring back the saturated brine from others, represents a very substantial sum. The large steam requirements of such a process mean an extensive, highly efficient steam-generating plant. The large volumes of brine and water to be handled daily call for an elaborate pumping system, and the operation of the multiple-effect vacuum pans calls for vacuum pumps and barometric condensers as auxiliary equipment. Fuel requirements are also substantial. A large plant will use 75,000 tons or more of coal annually or a corresponding amount of natural gas or fuel oil.

A huge volume of brine and water must be handled daily in a large plant, which may pump from 19,000,000 to 20,000,000 gallons of water and 750,000 to 850,000 gallons of brine every twenty-four hours. A set of vacuum pans 16 feet in diameter will produce 500 tons of granulated salt, and each "grainer" 10 tons of flake salt daily. The salt is pumped in the form of a slurry to rotary filters of the Oliver type, where it is dewatered and, by the passage of hot air through the salt "cake," or layer, on revolving filters, is dried down to a moisture content of less than 1 per cent. Final drying is accomplished by the use of rotary kilns.

The dried granulated salt is then stored in various bins according to the use for which it is intended. That to be used for table salt has been carefully screened to a uniform size. Filler (usually magnesium carbonate) is added to prevent caking and to make the salt free-flowing. In the manufacture of iodized table salt, 0.01 per cent potassium iodide is added, together with a stabilizer (a combination of a reducing agent and an alkaline agent), and so mixed with the pure salt that there will be no segregation afterwards. The table salt thus made is then packaged by means of modern high-speed, automatic or semiautomatic packaging equipment. The rest of the granulated salt is packed in 25-, 50-, or 100-pound cotton or multiwall moistureproof paper bags, or, at a pressure of 10,000 pounds per square inch, is pressed into 50-pound blocks for cattle. For some industries using large amounts of granulated salt in their processing, such as the meat industry, the soap industry, and the like, granulated salt is shipped in bulk in boxcars that have been lined with paper.

Flake salt—that produced in grainers or open-pan evaporators—is thoroughly dried and carefully screened to the various grain sizes required by food processors and other industries whose type of processing calls for a particular grain size, purity, rate of solubility, and special physical or chemical characteristics. For sanitary reasons this type of salt, when shipped to butter and cheese manufacturers, flour mixers, canners, etc., is usually packed in multiwall, moistureproof 100-pound paper bags. There are industries, however, such as the packing and the casing industries, which require this grain structure but who can use salt satisfactorily when shipped in bulk in paper-lined cars.

FIG. 4. Placing the explosive.

One of the most interesting of the solar evaporation operations is located at Newark, California. Situated on the east shore of the lower part of San Francisco Bay, the operation of the Leslie Salt Company covers more than 20,000 acres of level land, which is divided into ponds, some of them hundreds of acres in size. The ponds are separated by dikes and interconnected with an elaborate system of pumps and canals (Fig. 9). Sea water is admitted to the first ponds in March, and evaporation proceeds throughout the summer and early fall. The amount of evaporation depends upon wind, sunshine, and temperature and will vary from season to season. As the sea water concentrates, it is transferred from pond to pond, and finally, at the end of the summer season it reaches the last pond as a saturated soultion. It is pinkish in color because of the presence of salt water algae and a brine shrimp (*Artemia salina*). The shrimp lives only in concentrated brine and feeds on the algae, from which it gets its color. The following spring the concentrated brine is transferred to so-called crystallizing beds, which are from 28

FIG. 5. Hauling salt away.

to 40 acres in size. These beds are floored with a plastic clay, the imperviousness of which prevents loss of the now-valuable brine. The floor is made as level and smooth as possible. By early September, there will be about six inches of salt deposited on the floor of the crystallizing beds. At that point harvesting begins. Leslie Salt Company has developed for this purpose a sort of glorified bulldozer, whose blades are capable of exact adjustment so as to permit scraping up practically all the salt while avoiding injury to the costly floor. Temporary narrow-gauge tracks are laid on top of the salt bed, and the harvesting machine lifts the salt and spouts it into mine cars on the tracks on each side of the harvester. Mine locomotives transport the salt to the plant, where it is washed with pure brine and then placed on the storage pile, which may contain 300,000–500,000 tons of salt. The autumn and winter rains merely form a crust on this storage pile, and loss of salt from this cause is negligible. The bittern, or mother liquor, is pumped to a near-by chemical company which recovers the iodine, bromine, and magnesia. I believe this to be the largest and most efficient solar salt operation in the world.

Salt made in this way is coarse but very pure (running about 99.5 per cent sodium chloride), and it comprises the raw material of the Pacific Coast chemical and other industries using salt. In the manufacture of edible salt on the Pacific Coast, the solar salt is redissolved in pure water and then evaporated in multiple-effect vacuum pans, yielding an edible salt of extremely high purity, usually running at least 99.90 per cent sodium chloride.

The U. S. Bureau of Mines reports that in the year 1948 the total salt production of the United States was 16,303,293 short tons. This output far exceeds that of any other country; it is a measurement of our population, of the number of domestic farm animals, of agricultural activity, of food production, of chemical production, and general industrial activity. Of the total, 9,349,044 tons were produced in the form of brine by chemical companies and used by them; 3,846,846 tons were mined (rock salt); and 3,207,403 tons were produced by evaporative processes.

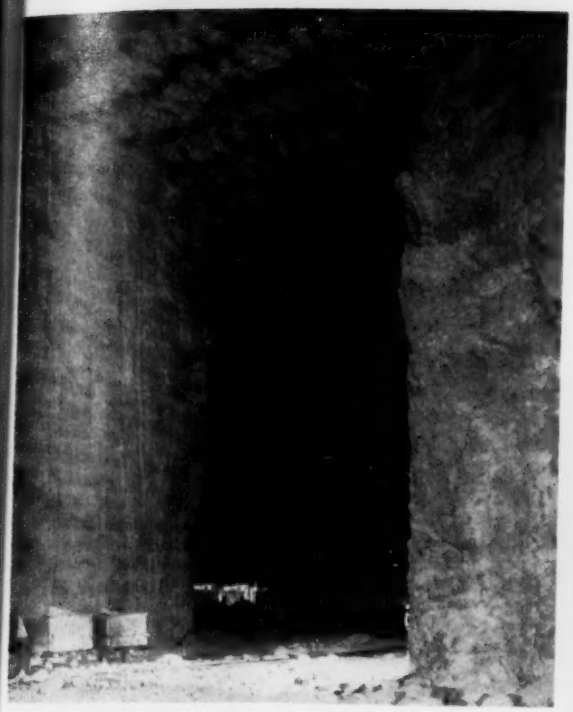


FIG. 6. Scene in mine at Jefferson Island, La.

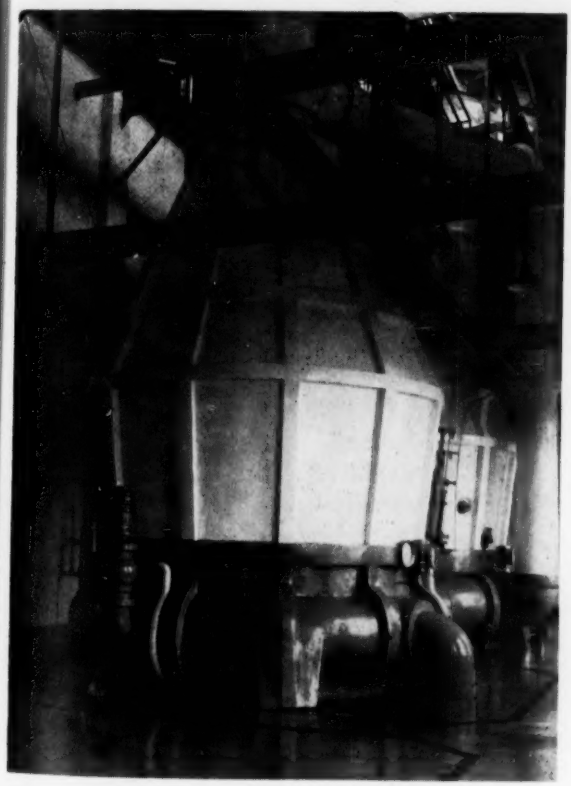


FIG. 7. Vacuum pans.

The layman thinks of salt as something used in cooking and on the table, but actually this is a minor usage, accounting for only about 4 per cent of the total salt produced. Where does all the tonnage go? And for what is it used? To answer these questions, the Bureau of Mines in 1941, as a guide to the War Production Board, sent questionnaires to all producers of salt, requesting a report on end use. The information has been gathered and reported annually since that time. The figures for 1948 are shown in Table 1.

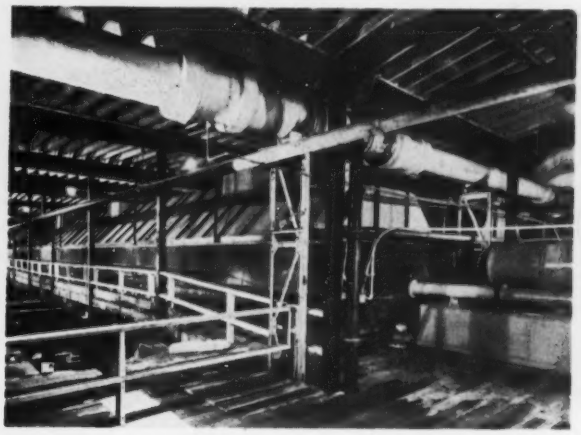


FIG. 8. Grainer, showing hood to conduct away vapor.

TABLE 1

END USE OF SALT 1948

(In short tons—2000#)

Chlorine, bleaches, chlorates, etc.	2,838,028
Soda ash	7,392,248
Dyes and organic chemicals	183,274
Soap (as a precipitant)	44,202
Other chemicals	615,266
Textile processing	115,393
Hides and leather	230,811
Meat packing	710,300
Fish curing	35,348
Butter, cheese, and dairy products	102,356
Canning and preserving	144,811
Other food processing	213,175
Refrigerant (car icing)	216,627
Livestock	792,518
Railroad and highway dust and ice control	468,934
Table and household	672,987
Water treatment (zeolite system of water softening)	446,956
Metallurgy	65,777
Not classified	1,144,502

The U. S. Bureau of Mines reports the salt production of other countries as compared with American production of 16,303,293 tons of salt in 1948 in Table 2.

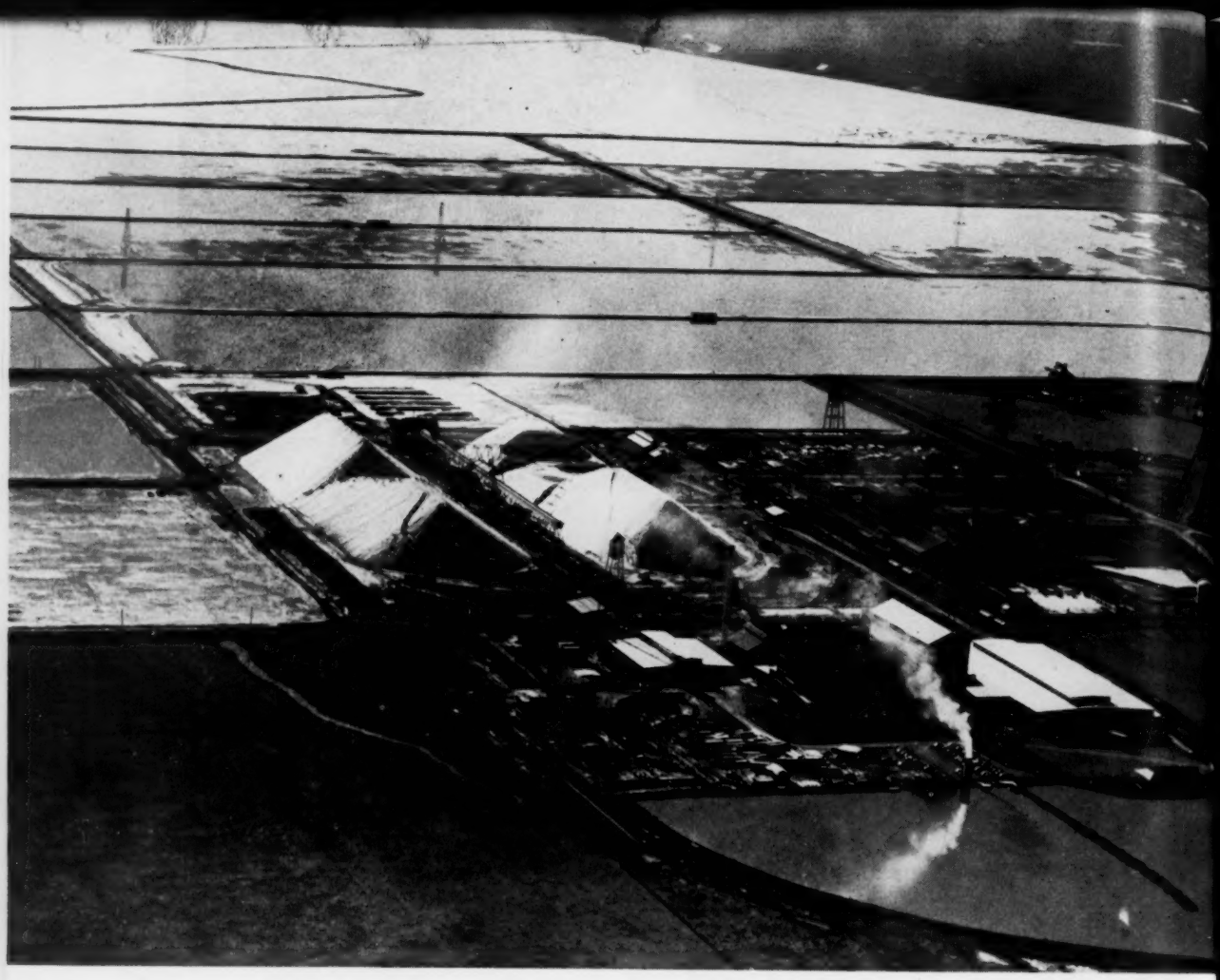


TABLE 2

(in metric tons)

Argentina	384,000—1947			
Brazil	609,198—1946; 1947	not	available	
Chile	59,405—1946; 1947	"	"	
Columbia	121,247—1947			
France	1,211,255—1946; 1947	"	"	
Germany	1,541,228—1946; 1947	"	"	
Austria	188,112—1947			
Rumania	314,485—1947			
Spain	772,772—1946; 1947	"	"	
Switzerland	95,435—1947			
United Kingdom	3,285,145—1945; latest figures available			

FIG. 9. Panoramic view showing Leslie Salt Company plant at Newark, Calif. In immediate foreground is the refinery, the undried salt shipping plant and machine shops. In middle background are outdoor storage stacks, and in the far background a small portion of the crystallizing and evaporating area.

Total salt production is thus another measurement of our industrial potential and capacity.

Figs. 1–5 by courtesy International Salt Company and *Friends Magazine;* Fig. 6 by courtesy Jefferson Island Salt Company; Figs. 7 and 8 by courtesy Morton Salt Company; and Fig. 9 by courtesy Leslie Salt Company.

The Changing Manpower Picture

PHILIP N. POWERS

Dr. Powers (Ph.D., Columbia, 1940), who is a physicist, has been in government service since 1942, first with the Naval Ordnance Laboratory, then with the Office of Naval Research, as advisor on scientific personnel with the President's Scientific Research Board, and, since 1947, with the Atomic Energy Commission as advisor on scientific personnel. His article is based on an address given before the Academy Conference at the New York Meeting of the AAAS last December. The opinions expressed therein are those of the author and not necessarily those of the Atomic Energy Commission.

AMERICAN science is riding on a steep upcurve. Everything about it, except perhaps the ages of its practitioners and the salaries they receive, has been on an exponential curve. In terms of dollars spent by the nation as a whole for research and development, we have moved from something over 150 million dollars in 1930 to about 350 million in 1940—more than doubling—then to around 2 billion in 1949. This represents not doubling, but a five- or sixfold increase during the forties, or well over a tenfold increase in the past two decades.

To be sure, dollars are not worth as much as they used to be. So the actual amount of research and development, however it might be measured, can hardly have increased that much. The value of a 1950 research dollar compared to what a research dollar could accomplish in 1930 has not, so far as I know, been determined. The "cost-of-living" dollar, however, has been periodically scrutinized. According to BLS figures, it takes $1.42 to buy today what you could buy for $1.00 in 1930. As shown in Figure 1, this suggests that our 2-billion-dollar research and development program is today worth only about 1.5 billion in 1930 dollars. But this is still about a ninefold increase over the two decades.

Another indication of growth is the number of science students in our colleges and universities. During the thirties enrollments increased by only 50 per cent, but in 1949 there were double the number of students that we had in 1940. Over the twenty-year period, there is therefore a factor of three.

Another measure of growth is found in the population of scientists. It is always difficult to know where to draw the line in counting scientists. The *Steelman Report* of two years ago stated that there were 137,000 scientists and engineers engaged in research and teaching in industry, government, and in higher education. This "Steelman population" of scientists was estimated at 46,000 in 1930 and 92,000 in 1940. The number of graduates in the science and engineering fields since 1947 suggests that this same "Steelman population" must now be in the neighborhood of 180,000, twice what it was in 1940 and four times what it was in 1930. Figure 2 illustrates the doubling during each decade.

There are many other indices of growth. During the past decade membership in the major geological societies nearly trebled, the number of pages printed in the various periodicals of the American Institute of Physics has doubled, and membership in the American Association for the Advancement of Science has increased from 20,000 to nearly 45,000.

Even more spectacular has been the growth during the past two or three years. One of the goals put forward by the President's Scientific Research Board was the doubling of the nation's research and development effort by 1957—ten years after the *Report* was written. It was then 1.1 billion; it is now around 2 billion. It appears that we are already trying to buy twice as much research with only a quarter of the decade behind us.

The *Steelman Report* also stated that there were enough students in school to permit doubling our total pool of scientists in a decade. In a little over two years this pool has been increased by about

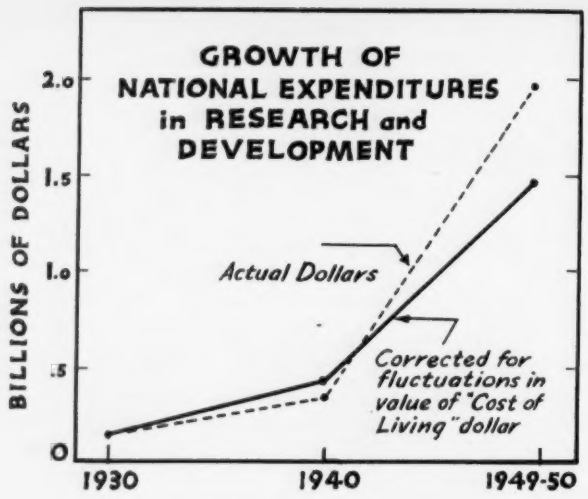


FIGURE 1.

30 per cent. The *Report* estimated that in 1948–49, 2,000 science Ph.D.s would be granted, about a hundred more than the highest prewar figure. Actually, there were not 2,000, but about 2,600. Including degrees in psychology, 1949's total was around 2,800. For comparison, Figure 3 shows the wartime low and the growth during the thirties.

The big immediate question about all this growth is whether job opportunities are still increasing in pace with the numbers of science graduates. We have heard a lot about the shortage of scientists. Dr. M. H. Trytten, director of the National Research Council's Office of Scientific Personnel, was one of the first to see the implications of the shortage developing during the war. In January 1945, in THE SCIENTIFIC MONTHLY, he said, "At the very best, it seems to me that we face a period during which the demands of a war-stimulated technology will not be met by an adequate supply of scientists and engineers trained to the necessary level of competence." This turned out to be a very accurate statement. In the same article, however, are some guesses about the rate of post-war recovery in the granting of degrees. The tone of these guesses is that by 1955 we might get back to somewhere near normal.

Six months later, the *Bush Report* also emphasized the shortage with the statement that "with mounting demands for scientists both for teaching and for research, we will enter the post-war period with a serious deficit in our trained scientific personnel." Two years later, the *Steelman Report* described scientific manpower as a "limiting resource" —limiting the expansion of research and development to a rate below what the nation really needs.

In none of these reports was the actual rate of increase in supply of scientists foreseen. No one guessed that in the school year 1948–49 our colleges and universities would confer more than 130,000 science degrees—over 30,000 more than the Steelman estimate of the total wartime-produced deficit.

The number of Ph.D.s awarded also has turned out to be many more than was predicted. The *Bush Report* estimated that the deficit of doctorates in science would accumulate till it reached about 15,000 in 1955. The *Steelman Report* lowered this estimate to about 8,500. Data now available indicate that the figure should be about 7,000. In each case these figures are estimates of the area in the war-induced dip in the curve of Ph.D. production. Another way of looking at it is that had there been no war and had Ph.D. production followed a smooth curve, we would now have 35–40,000 active Ph.D. scientists in the physical and biological sciences, instead of only about 30,000.

It may be that the phenomenally rapid increase in supply may be credited to these reports. It is as if the nation as a whole, in its own democratic way, heeded the word of these reports, believed in the value of science, and somehow pulled itself together to supply a larger number of scientists than any individual thought possible. This was done through the G.I. Bill, through an increase in the number of scholarships and fellowships, through feeding taxpayers' money into universities, through advice to young people to take up scientific careers, and in other ways. But, if we assume, as we must, that our society is as sensitive as this to its needs, then it is of the greatest importance that the need now be redefined as accurately as possible. As a nation, we should know how the scientific man-

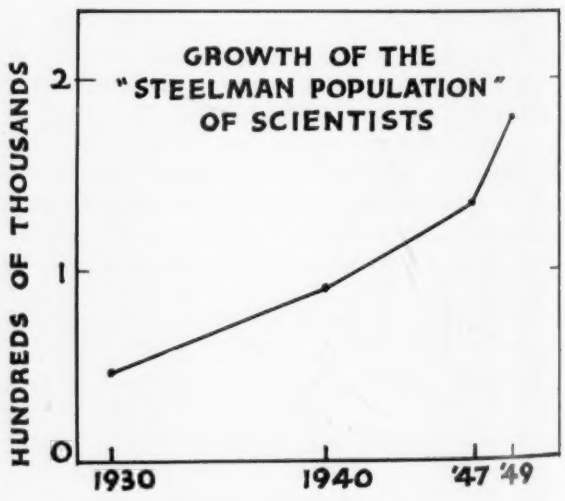


FIGURE 2.

power picture has changed and how it is likely to change in the future.

I

There are, in general, two approaches to the question. One is to observe long-term trends in supply and demand; the other is to take snapshots of current employment conditions—numbers of graduates placed against the numbers unemployed or working in nonscience fields. Use of both approaches provides a better picture than can either one alone. Except for some isolated efforts, however, very little is being done today along either approach; systematic study would produce far more accurate information regarding supply and demand than is currently available.

One of the most promising projects for the study of long-range supply and demand trends is one now planned jointly by four Councils—the National Research Council, the Social Science Research Council, the Council of Learned Societies, and the American Council on Education. Information from this Conference Board of Associated Research Councils indicates that financial support will come from the Rockefeller Foundation.

With funds for a two-year study, this group proposes first to examine in detail the kinds of activities in this country that depend upon the employment of especially trained people, whatever their fields of specialization. Next, information will be assembled on the innate abilities that people need to successfully receive training at these upper levels. Demand will be estimated through the gathering of data on such matters as the annual rates of employment and training, attrition rates in the various subject-matter fields, trends in appropriations of funds, rates of establishment of new institutions, and the creation of new kinds of activities and needs as the consequence of probable domestic and international developments. The study will also involve estimates of the proportions of the national population having ability to receive the training to undertake all these specialized types of work. Finally, the Four-Council Group will analyze the social factors that determine how many from this pool of outstanding people will be likely to actually get the necessary training.

There have recently been several more direct approaches to the supply-and-demand problem. Attempts have been made to measure the success of placement of graduates. For example, Professor H. H. Bliss, of the University of Oklahoma Chemistry Department, distributed a placement questionnaire to some 200 chemistry and chemical engineering departments. The replies from about 60 of them gave a clear indication that last June's Ph.D. graduates in both fields usually accepted employment well in advance of graduation, but that the conditions at the master's and bachelor's levels were progressively more difficult.

That the situation in chemistry was bad is confirmed by the experience of the Regional Employment Clearing House of the American Chemical Society. Alden Emery, secretary of the society, tells me that during the first part of this year the number of applicants increased rapidly, whereas the number of job openings decreased. For a time there was a strong indication that existing vacancies in the various companies were being easily filled by

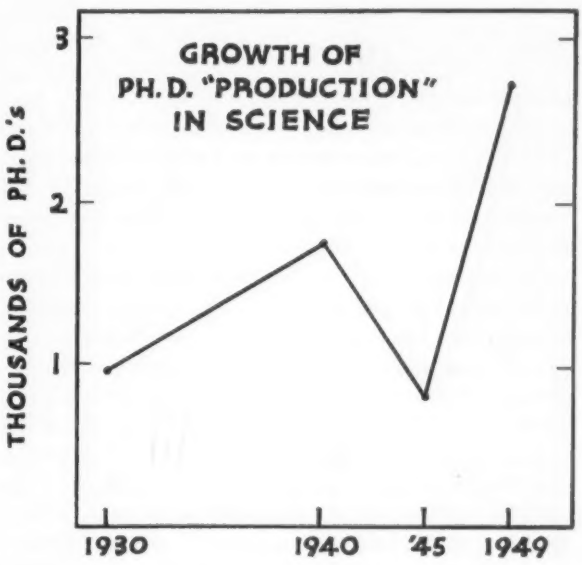


FIGURE 3.

applicants at the doors. There turned out, however, to be a sharp change following Labor Day. The Clearing House began to receive only about half as many applications; the number of employers registered began to increase along with the rate of withdrawal of earlier applicants. It therefore appears that the surplus that seemed to be evident in chemistry has not really developed and that, although next year's graduating class is going to be the largest ever, we do not have the data to predict accurately what the situation may be during this next year.

Other surveys of the sort that Professor Bliss attempted are needed. It is difficult in some cases for the chemistry and chemical engineering departments to provide placement data. Nevertheless, the collection of follow-up data, giving the numbers eventually employed, followed by annual sur-

veys for each graduating class, and extended to the other fields of science, would provide an excellent picture of the shifting demands for scientific personnel from year to year.

The geologists have the benefit of a report by the National Research Council's Committee on Geological Personnel. The Committee has analyzed both supply and demand and concluded that "as a result of the release of geologists who have served during the war in the armed forces and of the completion of the training of other geologists since 1947, the war-created deficit of geologists has been overcome as of the middle of 1949." Some of the larger companies in the petroleum industry reported that they do not intend to increase their geological staffs beyond the level of June 1949, and that thereafter they will seek new employees as normal replacements and to improve the quality of their personnel by obtaining more highly trained people. New needs for geologists will undoubtedly develop, but no systematic study has yet been made of what they may be. Supply-and-demand studies, however, to be made annually by the American Geological Institute, began in February.

Another placement survey was made by the General Survey Committee of the Engineers Joint Council. In a recent letter to the participating engineering schools, the committee chairman, M. M. Boring, reported that, as of November 1949, no more than 18 per cent of last year's baccalaureate engineering graduates was unemployed. Actually, the 18 per cent was the number of graduates who had not reported to their schools as being either placed or back at school as postgraduates. The real unemployment percentage must therefore have been much less than 18 per cent. The Boring survey had very good coverage—more than 34,000 graduates out of a nation-wide total of about 44,000.

The engineering profession has been well served by its Manpower Committee in the A.S.E.E. They have given a series of reports in which supply-and-demand estimates have been made. For example, in June 1947, the committee's report contained enrollment data, figures on probable hirings, a general discussion of the trends, and the prediction that the deficit of engineers would be overcome in 1949, with a surplus developing in 1950. This appears to have been an amazingly accurate prediction, and it is of much interest to note that it was in that fall of 1947 that enrollment in freshman engineering classes began to drop—and it was a considerably greater drop than the committee itself expected. Freshman classes as a whole dropped 15 per cent, but the freshmen engineers dropped over 25 per cent. It may be that reports of this kind have extremely important effects.

According to figures recently compiled by the Office of Education, the big engineering class is now at the senior level, and the junior, sophomore, and freshman classes are successively smaller than their predecessors in each case. The senior class is 18 per cent larger than last year, the junior and sophomore classes are each down 27 per cent, and the freshman class is again down by 13 per cent. If this trend does not reverse again, we may soon face another shortage. For the present, however, it seems that the timing of the drop-off in bachelor's engineering graduates matches to a remarkable degree the drop-off in demand.

The master's candidates are up 10 per cent over last year, and the Ph.D. candidates are up 22 per cent. It appears that the supply of graduate degrees will continue to increase, thus helping to match the continuing deficit of people at these upper levels.

II

The A.S.E.E. Manpower Committee is building an excellent record in spite of the real difficulty of making predictions of demand. Its experience indicates that surveys of probable hirings will not alone provide accurate estimates of future placements, but that the judgment of individuals with the sophistication to observe long-run trends in the needs and interests of the country as a whole is also an essential part of the process.

For example, the President's famous "Point Four" program probably means a greater demand for technical personnel. This program is still in its infancy, but, as I understand it, we are talking about American leadership in the growth of a world-wide technology. American dollars will apparently be needed, but surely the dollars should be accompanied by some of our technical talent. If we do the job that much of the rest of the world apparently hopes for, this program should increase materially the nation's need for scientists and engineers.

It may also be noted that national expenditures for basic research are far higher than ever before —perhaps as much as $150,000,000—depending on how you define it. If past experience is any guide, this $150,000,000 will lead to applied research on new products and new cures, costing many times as much as the basic research, and employing many times the number of people, but yielding large profits. The scope of basic research in itself therefore argues for an increasing demand for scientific personnel in the future.

These increases in applied research will be not only the result of the new knowledge coming out of basic research, but also the result of need. There is, for example, the need for research on how to get more water. This problem is not going to be solved overnight. But solved it will be eventually, by scientists and engineers. This means more jobs. The problem is, of course, not merely local. Water shortages are an old story in many parts of the country. It may be, therefore, that the eventual solution of this problem will create jobs for more than just a few scientists and engineers.

Other shortages of resources are beginning to develop. The amount of oil underground is limited. Sooner or later substitutes for oil will have to be evolved for all or many of its myriad applications. This will make more jobs, just as will the growing shortages of other mineral resources.

It appears, therefore, that the large flow of new knowledge coming from basic research, combined with both old and new scientific and technological problems, a cure for cancer, more water for cities, and so on, can only mean increases in applied science and more demand for research and development people. Furthermore, if there are more jobs to be filled, more teachers will be needed to train the people to fill them, and thus personnel needs will be compounded.

The opening of the atomic energy age should at least be mentioned in connection with the increasing demand for technical personnel. As of this date, the atomic energy industry employs only about 5 per cent of the nation's supply. Yet, for an industry that is only half a dozen years old and that cannot yet be freely developed through private initiative, that is a large percentage. The future of nuclear reactors is unknown, but the demand for people to work in this field is certainly increasing today. The atomic energy age has brought with it more radiation on the earth's surface than mankind, at least, has ever experienced. We have so far seen only the beginning. Living with this radiation, not only to protect ourselves from it, but to realize its benefits, is going to require more technically trained people.

The growth of the nation's total research and development budget also deserves some scrutiny. The *Steelman Report*, two years ago, said: "For the next two years, there will be too few scientists to permit the substantial expansion of research and development programs that the nation requires." Yet during these two years we have seen a near doubling of research and development expenditures. How could this happen? The number of scientists and engineers has increased remarkably, but it has not doubled; at the most, it has increased by a third.

Accurate data on how our 2 billion dollars of research money are being spent is not available, but a simple calculation shows that on the average the amount of money spent on each scientist has greatly increased. Not counting the teachers, each scientist in 1930 and in 1940 cost, including salaries, about $6,000; but in 1949, the cost was nearer $20,000. Salaries dropped during the thirties, but they are now up again and exceed by only 5 or 10 per cent what they were twenty years ago. If a salary of $4,500 is assumed to be close to the average in each case, it develops that the amount of money spent by a scientist has increased approximately tenfold.

There are at least two good reasons for this big increase: the dollars are worth less, and scientists are doing a great deal of building. They are constructing laboratories, getting new equipment, and making some very large and expensive research gadgets, cyclotrons, nuclear reactors, etc. With money easier to get than trained people, and with new needs for expensive equipment, the rate of building of research facilities is at a new high.

It also turns out that this big budget is mostly government money. Dr. Steelman announced recently that the Federal research and development budget for the current fiscal year is about 1.4 billion dollars—more than double what it was in 1947. Much of it is spent outside the government —more than $100,000,000 in colleges and universities, and more than $300,000,000 in industry.

This current large-scale expansion of government-owned facilities suggests that as they are completed more scientists and engineers will be needed to operate them. A systematic analysis of these facilities could provide a much clearer picture than we now have of the numbers and kinds of additional positions that are likely to open up in government or in government-owned but privately operated activities.

III

In spite of all these trends adding up to increasing demand, the question still remains as to whether the demand will increase as rapidly as the supply. Without recourse to special studies, it is obvious to anyone who has been recruiting scientific personnel that the shortage is no longer as acute as it was. But there are still unfilled jobs, even though there are scientists without jobs. The point is that we are moving out of a period in which supply has been quantitatively less than demand into one where supply and demand are qualitatively out of balance. A surplus of persons,

perhaps a serious surplus, is developing in certain categories; but at the same time the shortage continues, or perhaps even gets worse, in certain other categories.

It is indeed inevitable that such an unbalance should exist and should get worse as the pace of science increases. The only question is the degree of unbalance. Depending upon the amount of specialization, somewhere between four and ten years are required to train a scientist. Decisions as to fields of study may therefore be made as much as eight years before the training is to culminate in professional employment. It is manifestly unlikely that individuals will make all these decisions in proper proportion to the demand developing years ahead—particularly if whole new fields open up in the meantime. Training in fundamentals is of course the best protection against being left out on a limb when schooling is completed, but even the fundamentals are so numerous that decisions have to be made as to which shall be learned.

This is the basic reason why American science, as it continues to grow, must have for its own guidance the best information that can be gathered regarding the trends in its growth. Science students, and their counselors and teachers, require this information to make the best decisions in planning educational programs. There can and must be no control over how many students choose a given field, but the students making the choices should have the facts that will help them to judge what future demands may be for work in the various fields in which they may be interested.

Certain elements of the developing unbalance are clear. The demand for senior scientists and for scientists with administrative skills is far above the supply. The atomic energy industry has given rise to unfilled demands for engineers in the reactor development fields and to persons with knowledge of both the physical and biological sciences for work involving the effects and uses of high-energy radiation. Not enough people are available in these fields even though surpluses of chemists, biologists, and engineers may be developing.

Other sources of unbalance may be expected to develop from the new kinds of personnel needs arising as a direct result of the increasing bigness of science. In addition to the growing demand for scientists with the administrative skill to lead large research teams, more people are going to be needed with the knowledge and ability to catalogue, summarize, and abstract results of research. There was a day when well-trained people carried around in their heads most of the significant literature in their fields. This day is passing. The volume of research reporting is becoming too great. From now on a larger proportion of the scientific population is going to have to work simply at spreading information about the results of research. The increasing bigness of science is also likely to produce a need for more scientific generalists—persons who specialize in broad fields of science rather than in narrow ones.

There is, of course, another kind of unbalance that is always inevitable—a surplus of the poorly trained and a shortage of the well-trained. We must ask whether there are enough really top-notch people coming out of the schools—future Nobel prize winners, say. Are the Faradays, Newtons, and Darwins rising to the surface in our present-day educational system? On the other hand, how about the incompetents? How many people are graduating who are not qualified to do well in the positions they will try to get? If these people are unemployed as scientists, do we conclude that there is a surplus of scientific personnel, or do we simply have people who have been encouraged to apply for work which they could not perform if they got it?

Until now the numbers of unemployed even in this group have been trivial. The demand has been so high that it has drawn persons with marginal qualifications into good jobs. The result is that today, now that the supply is greater, there is some house cleaning going on. In fact, it may turn out that one of the main features of the scientific manpower picture during the next few years, apart from the development of new areas of demand, will be the gradual replacement of less qualified by more highly qualified people, particularly in the more crowded fields.

IV

It is clear then that the "shortage-of-scientists" problem, as we have known it during the past few years, is about over. Coming into focus, instead, is the new problem of keeping supply and demand in balance. Instead of a simple need for more scientists of all kinds, the question now is what kinds. The problem is to avoid the spectacle of unemployed scientists on the streets in front of institutions that cannot locate scientists qualified to do what needs to be done.

With the simultaneous growth in both supply and demand, the unbalances that may result are of three kinds: First, unmatched proportions among the various fields of specialization; second, unmatched proportions among skill requirements such as teaching, editing, management, doing applied and developmental research, and so on, perhaps

even including skill in working with people; and, third, unmatched proportions among levels of competence ranging from ability to win Nobel prizes or administer major research programs to the usual postdoctorate and postbaccalaureate levels.

Basically, two kinds of data are needed to deal with this problem: detailed information about scientific personnel resources—numbers and kinds, extent of education, how employed, numbers in training, and so on; and information about the nation's total science program—kinds of research and development, kinds of other activities that require scientists, rates of growth of various segments of the science program, the different fields involved, and many considerations other than just dollars spent.

In short, we need systematically and continuously to gather facts about scientists and their jobs. Up-to-date facts in these areas in the hands of college and university students and faculty would go far toward insuring balance in the future and with it the best utilization of our scientifically trained people. Educational institutions could use these facts in deciding upon such matters as standards of admission, graduation requirements, establishment of new courses of study, curriculum revisions, and in advising students. The result would be the graduation of students with the specialized training required to meet new needs as they arise. This kind of planning would be the best possible insurance against having an unemployed surplus of certain kinds of scientific personnel and a critical scarcity of others.

BEWILDERED INHERITOR

The egg, perfection in geometry,
Seems so discrete
As if those transiencies—
The fish, the bird, the pig—
Did not exist
(Do they persist?)
Beyond the pulsing moment.

How comes the clouded distillate
In this unangeled genesis?

The moment's mold,
So malleable,
Is fired hard
To guarantee
Each fleeting form
In its alloyed estate.
It cannot be denied,
Or brushed aside;
Nor feathers put on fish,
Or wings on pigs.

JOSEPH HIRSH

Further African Studies*

WENDELL PHILLIPS

Since his return from the University of California African Expedition, Mr. Phillips has organized two other expeditions: the American Foundation Mount Sinai Expedition, operating under the field direction of William Terry, which is conducting an extensive study of the library of the monastery of St. Catherine at Mount Sinai on behalf of the Library of Congress; and the American Foundation Arabian Expedition, of which the author is personally in charge. A major archeological program is being carried out along the ancient frankincense-spice route of Southern Arabia.

Tropical Medicine

THE University of California's African Expedition, after completing its work in the Sudan (*cf. Sci. Mon.*, 1949, **69**, (10), 262–69) next established its headquarters in East Africa at Njoro and Nairobi, the center for medical and veterinary research in the area. A study of the local work was made and a short survey trip to Italian Somaliland undertaken. In the Nairobi vicinity, an important series of the blood parasites of domestic animals was obtained, particularly a large number of slides illustrating East Coast cattle fever. Clinical photographs and pathological material were secured on a number of exotic diseases, among which were yaws, human anthrax, kwashiokor, and Rift Valley fever. At Njoro the expedition collected the small mammals primarily concerned with human disease as reservoir hosts; among them were a number of rare and new species. Each specimen was examined for both external and internal parasites.

The Mombasa area of Kenya is hyperendemic for malaria, and this fact, in addition to the existence of the large British staging area at MacKinnon Road, offered an excellent opportunity for studying problems confronted by the British Army Medical Service and the methods by which they have been solved. A small clinical trial of chloroquin, both as a suppressive and in the treatment of malaria, was made here; it is believed that this is the first trial of the drug in East Africa.

* The field staff of the U. S. Navy Medical Science Group of the University of California African Expedition included Captain James J. Sapero, MC, USN, medical officer (directed medical program Nairobi to Cape Town and Madagascar); Commander Julius M. Amberson, MCR, USNR, medical officer (directed medical program Cairo to Nairobi); Commander Trenton K. Ruebush, MSC, USN, parasitologist; Harry Hoogstraal, mammalogist-entomologist; Dr. Ernest Schwarz, zoologist; Chief Hospitalman Deaner K. Lawless, USN, medical research assistant; Photographer's Mate 2/c Harley F. Cope, USN, Naval photographer; Richard Alison, assistant mammalogist; and Walter Thompson, technical assistant.

Henry Hoogstraal and Deaner K. Lawless returned to Torit in the Sudan to attempt an elucidation of the life cycle of the elephant shrew malaria. Although they failed to find the intermediate host for this malaria, they did discover eighteen malaria and malarialike organisms, six trypanosomes, and three microfilaria in thirteen species of animals. These forms are at present being studied at the Naval Medical Research Institute; a number of them have proved to be new and of particular interest to science.

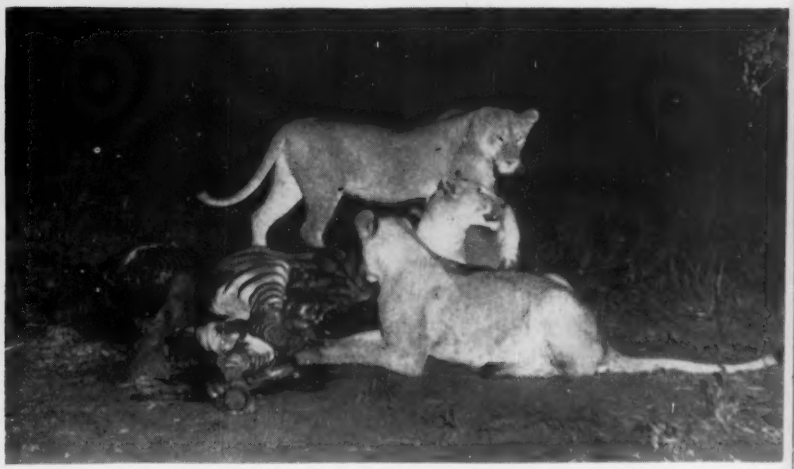
An interesting and profitable visit was made to Entebbe and Kampala, where the medical school, main hospital, pathological, entomological, and veterinary laboratories and the office of the director of medical services for Uganda are located. The famed Rockefeller yellow fever research laboratory is at Entebbe, and the field laboratory and experimental station at Bwamba. Headquarters of the Colonial Insecticide Research Institute are also at Entebbe. (At Kampala, Commander Amberson undertook a complete post mortem on an untreated victim of Rhodesian sleeping sickness.) From the pathological and veterinary laboratories quantities of specimens of diseases of man and lower animals were obtained. Of especial importance was the opportunity to see and study yellow fever research in East and Central Africa, and color motion pictures were made to show the epidemiology of the disease. Color movies were also taken to show sleeping sickness epidemiology and control on the Sese Islands in Lake Victoria. Information on the incidence and geographical distribution of disease in Uganda was also obtained, and the entomological laboratory at Uganda presented the Naval medical group with a very fine collection of the insects of medical importance in this colony, including, of course, tsetse flies.

In the Belgian Congo, Blukwa is the center of interest, for here is located the research center for the study of plague and schistosomiasis. Rare pathological specimens of human plague, both bubonic

Pygmy family around the fire. Woman on left is making a porridge out of green bananas that have been dried in the sun, pounded into powder, and cooked with water. The green banana is also allowed to dry out and is then put into the fire and roasted, becoming a favorite food.

William and Gladys Terry and Pgymy of e Ituri Forest examine poisoned arrow.

Night picture of lion feeding on the carcass of a zebra (Kenya).



Professor Mitwally, anthropologist of Farouk University, Alexandria, measures a Watusi native in Ruanda Urundi.

Watusi native high-jumping to a height of well over seven feet. This is a well-known accomplishment of these people, but they are debarred from national tournaments because they refuse to jump without the aid of rock shown in this photograph.

and pneumonic, of the rodent reservoir hosts, and of the flea vectors were added to our collections here, as well as specimens of two unusual human parasites, a microfilaria, *M. streptocerca,* and a schistosome, *S. haematobium* var. *intercalatum.* At the pathological laboratory at Stanleyville a large series of pathological specimens of the exotic diseases of the Congo was acquired.

The sleeping sickness research laboratory at Tinde and the tsetse fly research laboratory at Shinyanga, Tanganyika, were visited, in addition to all the dispensaries and hospitals en route, and a composite view of Rhodesian sleeping sickness was obtained. An extraordinarily fine collection of tsetse flies in all stages of development, including the rare laboratory hybrid *Glossina swynertans,* was presented to the Naval medical group. Pathological specimens, blood slides of *Trypanosoma rhodesiense, T. gambiense,* and *T. brucei,* together with unique salivary probe smears, alone made the visit worth while.

Tanganyika Territory's main pathological laboratory, and the director of the medical services, are located at Dar-es-Salaam, as well as large hospitals both here and at Zanzibar. As with all the other places visited, the expedition members obtained a rather complete picture of the incidence and distribution of disease in this area, and the medical group was fortunate enough to be able to study an epidemic of typhoid fever on Zanzibar.

In Madagascar, the research was conducted by Harry Hoogstraal, Deaner K. Lawless, and Richard Alison, and Captain Sapero made a brief inspection visit after the work had begun. The purpose of the investigation was to make a preliminary survey of the blood diseases and infections of the native fauna. Apparently no records of malaria and other blood protozoa, filaria, or trypanosomes had ever been made from the island. Aside from the interest in extending the known range of the local diseases, the possibility of correlating whatever might be found with the evolutionary trends of the fantastic Madagascar fauna enhanced the desirability of the project.

Although only two months were actually spent in the field, the results were eminently satisfactory. Several species of malaria and other blood protozoa were found in the vertebrate fauna, together with numerous filariae and some trypanosomes. Among the zoological collections made in conjunction with the work, several animals stand out. Three specimens of an aberrant family of bats, considered one of the great zoological rarities of the world, were collected, thus doubling the known collections of this family. Several specimens of adults, nests, and eggs of one of the rarest and most curious of Madagascar birds were secured, and the known range of the bird was considerably (and surprisingly) extended; the nesting habits of this species have hitherto been the subject of conjecture. A *Lemur catta* was brought back alive for growth and functional anatomy studies.

Leaving Tanganyika, the expedition passed over the great north road through Northern Rhodesia. All the hospitals and dispensaries along the route were visited, and information and clinical photographs collected on the endemic tropical diseases. Salisbury is the center for research on schistosomiasis, and a fine series of pathological specimens of schistosomiasis was obtained here. Of particular value were post-mortem snips of both bladder and rectum showing schistosome ova. Excellent specimens of the adult schistosomes were also presented to the Naval medical group, and information on the incidence and distribution of endemic disease for Northern Rhodesia was obtained at Salisbury and, for Portuguese East Africa, at Lourenco Marques. Specimens of the rare and interesting hookworm, *Ternidens deminutus,* were collected in Portuguese East Africa.

In South Africa, Johannesburg and Pretoria are the centers for medical research. Although diseases in this area are in large measure similar to those occurring in our own country, the information gathered at the various research centers proved to be interesting and valuable. From October 23 to December 24, 1948, Captain Sapero visited Madagascar, the Belgian Congo, French Equatorial Africa, Nigeria, the Gold Coast, Liberia, Sierra Leone, French West Africa, and French Morocco, and secured firsthand information on the endemic diseases in these regions.

Anthropology

In physical anthropology, studies were made of the Masai at Ngong, in the Selengiei-Mashuru region, and at Kajaido, and an English-Masai vocabulary and phrase book were compiled for the first time. Dr. Henry Field was in charge of this research. Professor M. Mitwally, of Farouk University, conducted studies in physical anthropology in Kenya, Uganda, Zanzibar, the Belgian Congo, and Northern and Southern Rhodesia. Extensive firsthand information on the social life and economic conditions of the Jaluos and Bantus in the vicinity of Maseno, Butere, Nigi, and Kisumu was obtained. In and around Nairobi, measurements were made of the Nandi, Kamba, and Kikuyu, and in the Mombasa coastal region, on adults of the Digo and Giriama tribes.

In Uganda, 350 representatives of the two major tribes, the Buganda and the Bunyore, were measured and studied at Kampala, and at Fort Portal, 80 members of the Toro tribe, the first anthropometric studies to be conducted in this region.

Anthropometric measurements and studies were made on adults of the Wahadimu, Watembatu, Wampemba, and Shirazi tribes (Zanzibar). It is interesting to note that, as the members of these present-day Zanzibari tribes are not negroid, the name *Zanzibar* ("The Land of the Blacks") is a misnomer. The Zanzibari are a mixture of different races, to which the Persians of "Shiraz," the Arabians of southern Arabia, and the African Bantus have contributed a great deal. Since the Bantus are not pure negroids, but a mixture of Hamite and negroid elements, it is easy to understand that a high percentage of the blood in the present population is Asiatic. This mixture is the result of the waves of human immigration from Persia, Iraq, and southern Arabia which followed along the sea route drawn and defined by the monsoons that sweep over the northern part of the Indian Ocean.

Temporary headquarters in the Belgian Congo were established at the American missions in Oicha and Lolwa in the Ituri Forest west of the Ruwenzori Mountains. More than 200 adults, both male and female, were studied in twelve different camps of the Bambutti, or Pygmies. The information collected on their way of life added supporting evidence to the view that some sort of relationship exists between the Pygmies of the Ituri and the Bushmen of the Kalahari Desert. It is possible that these two peoples are derived from one racial stock, which at a certain time must have populated the greater part of the African continent. When the stronger racial elements came to the continent in successive waves, these primitive people retreated to the most inhospitable regions, seeking shelter in the equatorial forest of the Belgian Congo and in the Kalahari Desert.

In Ruanda Urundi, around Rutchuru and Nyanza, the Watusi represent one of the racial elements that entered the Congo as conquerors, and they live in the open areas surrounding the equatorial forest. Anthropometric measurements were made of 100 male adults. By far the tallest people in the world, the Watusi stand out in abrupt contrast to the Bambutti, who live in adjacent areas. One can easily notice Abyssinian traits in their features, and they appear to be the remnants of an Abyssinian army that invaded the region some hundred years ago.

A representative sample of two linguistic groups (the Tonga and the Rosi), which are found in both Northern and Southern Rhodesia, was selected, and anthropological measurements were made on about 150 individuals in Livingstone and Wankie.

An old Arab dhow in Zanzibar harbor.

Paleontology

The work in invertebrate paleontology was conducted by Professor G. H. Awad, of Farouk University. In Kenya collections were made of Upper Jurassic fossils from both old and new localities. These comprised 300 specimens representing more than 50 species of ammonites from the Kimeridgian, Argovian, Corallian, Oxfordian, and Callovian. Pliocene and Pleistocene mollusks were collected from the north Mombasa crag and other localities. Recent shells and land snails were collected from Ports Reitz and Tudor and also from the coral beaches at Nyali and Malindi.

Nairobi is situated in a volcanic area, the rocks being mainly alkali-type lavas. Since alkali lavas are not known from Egypt, a representative collection from the typical outcrop localities was made for Farouk University for teaching purposes.

On the island of Zanzibar, only the Pliocene and Pleistocene are represented, and fossils are rare and generally not well preserved. The only fossiliferous Pliocene on the island, the *Pecten werthi* beds, yielded some mollusks, however. The Mazingini Sands, overlying these beds, are nonfossiliferous, but they are of interest for the type of erosion

they present. This results in the formation of the picturesque earth pillars such as those found at Walezo. Additional work was done on the Azania series of the Pleistocene, and fossil gastropods and lamellibranchs were collected at Kisambasi.

In the Wankie coal field, seventy miles southeast of Victoria Falls in Southern Rhodesia, the shale is soft, and the fossil plants are beautifully preserved as impressions practically devoid of any trace of carbonaceous material. The most abundant were various species of *Glossopteris,* but there were also representatives of *Cyclodendron, Cordaites,* and *Phyllotheca,* all of which are characteristic of the southern Gondwanaland flora. Great interest attaches to the association of seeds with the *Glossopteris* leaves, and a specimen collected by Cooke ten years ago appears to show an attached seed, thus confirming the similar association known in Australia. In the Wankie flora typical northern forms such as *Pecopteris, Sphenopteris,* and *Sphenophyllum* are also plentifully represented. The affinities of the flora equate it with the middle Ecca series of the Union of South Africa, which are of mid-Permian date. The major part of the fossils collected in this area was sent to Professor Ralph W. Chaney, of the University of California.

Near Lourenco Marques, Mozambique, Cretaceous invertebrates were found. From Catuane on the Natal-Portuguese border came large ammonites, some small belemnites, and a few pelecypods and gastropods. Among the ammonites was *Ancyloceras,* of perhaps Aptian age. At Porto Henrique, on the left bank of the Rio Changulane, recent road excavations have exposed greenish marls under terrace gravels, and from these marls dwarf marine species, possibly of Tertiary age, were recovered. A few miles west of this site limestone quarries, hitherto believed to be lower Cretaceous, yielded a variety of mollusks, including genera closely resembling *Divaricella* and *Pectunculus,* which may indicate that the deposits are perhaps later than has been supposed. Miocene or Pliocene marine fossils were collected at Delagoa Plantation, near Magude, sixty miles north of Lourenco Marques, and hand axes of early Stone Age were found at Magude itself. Two sites near Lourenco Marques furnished Pleistocene fossils, mainly oyster, from old raised beaches. It is apparent that the level of the sea has undergone many changes since man first inhabited the region. Forty or fifty miles away from the modern coast line and 150 feet above present sea level are beaches containing numerous early Stone Age implements.

The bone breccia deposit at Swartkrans, South Africa, near the famous Sterkfontein Cave, has been known for at least ten years, but it remained untouched until November 1948, at which time Dr. Robert Broom and his field assistant, J. T. Robinson, of the Transvaal Museum, collaborating with the expedition, carried on extensive excavations. The deposit is the floor of a moderate-sized cave; most of the walls were weathered away.

As soon as this deposit was opened up, it was found to be fairly rich. In the first week much of

Mandible from the Swartkrans ape man found in April 1949 by Dr. Robert Broom while engaged in excavations for the University of California African Expedition. Natural size.

the lower jaw of an ape man, which on examination has proved to belong to a new species, was discovered. The teeth, although essentially human in structure, are remarkably large—larger than those of any of the ape men previously known. It has been named *Paranthropus crassidens.* Besides the mandible, which is that of a young male, three upper teeth were found—two incisors and a canine of the same individual. These are almost typically human and very unlike the corresponding teeth in apes. Later, a well-preserved palate with the premolars and molars of a middle-aged female was found, and on April 1, 1949, the almost complete mandible of an adult. This jaw is huge—far larger than any previously known jaw of any man or pre-man, except perhaps Meganthropus of Java, which unfortunately is only known by a small portion of a jaw. The front of this new jaw is almost straight, and it does not slope away as does that of the apes. It is also remarkable in having a rudimentary chin. Another discovery was of a radius, which was of such a character as to indicate that the arm was feeble and unsuited for walking upon.

Most of the skull of a new type of baboon allied to the mandrill has been uncovered, plus imperfect lower jaws of this and another type of extinct baboon. In addition, there is a very fine skull of an extinct type of hyena, belonging apparently to the European genus *Lycyaena,* two imperfect jaws of a new type of cat allied to the leopard but smaller in size, and three skulls of a small golden mole, which is probably new. Other specimens include two small carnivore jaws and many antelope remains, but these have not yet been critically examined. So far no remains of pigs, horses, rhinos, or elephants have been found at Swartkrans.

Entomology

In association with the Transvaal Museum, through the cooperation of its director, Dr. V. FitzSimons, Dr. Karl Koch and Dr. G. Van Son conducted extensive entomological explorations in the desert regions of the Karroo, Namaqualand, and Bushmanland between the mouth of the Orange River and the Bay of Luederitz, up to the southern Namib Desert, where the main work was done. Insects had never before been collected in this area. Approximately 10,000 specimens of Tenebrionidae, plus a few termites (extremely rare in the barren Namib), were collected; more than 80 per cent of these species were missing in the Transvaal Museum collections. The number of forms new to science comprised at least 10–12 new genera and approximately 150–200 new species and geographical races of Tenebrionidae.

It was found that the Orange River is not a barrier for the distribution of the Tenebrionidae and that it does not limit a faunal district. The same species, mostly very ancient apterous forms, occur north and south of the river, but the deep valley of the Holgat River, recently dried out about twenty-five miles south of the Orange, seems to have a certain importance, for a strong change in the composition of the fauna occurs there.

The autochthonous Tenebrionid fauna of the Southern Namib is strictly limited to the ecological element of the shifting sand dunes. The fauna of all the other biotopes, such as rocks, sandy soil, windblown sand, littoral belt, etc., is a typical immigration fauna, originating from the continental regions of Bushmanland and Karrooid parts of the Southwestern Kalahari. It was discovered that the Namib also contains elements of a very old endemic fauna of a territory which seems to include also parts of Bushmanland, of Southwestern Kalahari, and of Damaraland. The limits of this ancient fauna district, which contains Saharo-Gobian relicts, have yet to be investigated.

The presence of Saharan relicts in the South African Tenebrionid fauna is further demonstrated by the discovery of a new genus of the *Calognathini* in Bushmanland and of the Saharo-Turcmenian genus *Cyphostethe* in Northwestern Namaqualand. South African descendants of an original Saharo-Turcmenian stock were until now unknown to science, and their discovery opens up an interesting line of research in the study of the development of the fauna of South Africa.

In the characteristic separated stony hills of the flats of Namaqualand, Bushmanland, and Namib, there was discovered a petrophil fauna varying specifically from hill to hill, which has arrived at the extreme of endemism. These highly endemic Tenebrionids represented by one paleogenetic line demonstrate the existence of an ancient continuous mountain range in this part of the country, which is today broken into hundreds of single hills by erosion. A similar but much more recent endemic fauna, due to isolation, was discovered in shifting sand dunes, separated from one another sometimes by only a few miles.

The high and barren continuous "sand sea" of the southern Namib shelters a rich fauna of wingless Tenebrionidae, morphologically adapted to life in this hot and barren land in the most extreme way. This fauna is exclusively limited to the Namibian sand dunes. The process of adaptation is found here to a point of perfection and much more developed than in other Tenebrionids.

Darwin and the Heterotroph Hypothesis

GARRETT HARDIN

Although he pursued a fairly conventional career in biology, leading to a Ph.D. from Stanford in 1941, Garrett Hardin has frequently wandered off into byways that logical positivists call "metascience," inquiring into questions of the philosophy and organization of scientific activities. After four years' research at the Division of Plant Biology of the Carnegie Institution, Dr. Hardin in 1946 forsook the laboratory for the classroom, specifically for the University of California's Santa Barbara College. Readers of THE SCIENTIFIC MONTHLY *may recall "The Last Canute" (September 1946), an article in which he satirized the activities of librarians and scholars. It is interesting to observe that the following historical notice, implicitly by its existence, and more than implicitly in its concluding paragraph, casts doubt on the ingenuousness of the Canute article.*

REGARDING the origin of life there are at the present time only two scientific hypotheses that are given serious consideration. Using designations previously proposed,[1] we may call these the "Autotroph Hypothesis" and the "Heterotroph Hypothesis." According to the former, the first form of terrestrial life must have been some organism that could manufacture its own organic substance out of inorganic substrates, as can contemporary green plants. The Heterotroph Hypothesis, on the other hand, states that the first "organism" was one of severely limited synthetic abilities, subsisting on a readily available menu of organic materials formed by nonvital processes.

If we limit our inquiry to modern times, it is certain that the Autotroph Hypothesis is the older of the two, and it is probable that it is still the one more widely held among the majority of biologists. The most powerful argument against it has developed from enzyme and vitamin studies of the past three decades, studies which indicate that, as a generalization, all organisms may be said to be dependent on the same fundamental biochemical reactions, and that the lesser nutritional needs of the autotrophs are consequences of their greater synthetic abilities, which in turn are made possible by their greater arsenal of enzymes. We see, then, that the Autotroph Hypothesis implies that the more complicated organisms were produced first; the hypothesis is, therefore, untenable.

Only the Heterotroph Hypothesis is readily reconcilable with the facts of biochemistry. This hypothesis had its first forcible promulgation in a book by Oparin,[2] published in English in 1938. Oparin pointed out that there are many ways whereby organic substances can be synthesized by nonorganismic means—for example, by the action of ultraviolet light on a mixture of water, ammonia, and carbon dioxide. It is therefore possible that, at an early period in the earth's history, there could have been—to use Haldane's phrase—an ocean of hot, dilute soup in which the process of abiogenesis could have taken place. Oparin's speculations have been brilliantly elaborated by Horowitz[3] into a tenable scheme whereby the principle of natural selection could, by a logical series of steps, bring about the evolution of autotrophic organisms from the original completely heterotrophic self-duplicating entity.

The logical basis of the Heterotroph Hypothesis seems almost self-evident today; yet, like many "self-evident truths," it is arrived at with the greatest of difficulty. Why is this? How can the obvious be so readily overlooked? The central psychological difficulty would appear to derive from an unconscious residue of the older theories of heterogenesis. Before Pasteur gave the *coup de grâce* to these theories, it appeared that two things happened when one attempted to accumulate organic matter: (1) the organic matter produced living organisms; and (2) the organic matter spontaneously decomposed. The experiments of Pasteur (and others) gave the lie to both these statements. By discrediting the first, Pasteur made a theory of

abiogenesis more difficult to conceive; but, by showing that the second event does not occur, he laid one of the necessary cornerstones of the modern Heterotroph Hypothesis. Oparin showed a clear realization of this fact when he said that a

> condition essential for the origin of life is the possibility of prolonged transformations, of prolonged evolution of the primary organic substances. Organic substance is the building material out of which the complex structure of living organisms could be formed. As will be shown subsequently, to accomplish this transformation from substance to organism requires a very long time. At the present time such a transformation is entirely out of the question because, if organic substance originated anywhere on the earth's surface, it would be extremely rapidly devoured and destroyed by the countless microorganisms inhabiting the soil, air and water. But before life had yet appeared, the Earth, of course, was entirely sterile and the organic substances which were formed could evolve in many different directions for a very long period of time. However strange this may seem at first sight, a sterile, lifeless period in the existence of our planet was a necessary condition for the primary origin of life. This condition prevailed only in the remote past but does not exist now, since the surface of the Earth is already thickly populated by innumerable highly organized living things.

Historically, the English publication of Oparin's work in 1938 was the effective stimulus to present-day thinking in this field. The essence of the argument was, however, clearly stated by J. B. S. Haldane in an essay written ten years earlier, and published in book form in 1933.[4] In Haldane's words:

> In this present world such [organic] substances if left about, decay—that is to say, they are destroyed by microorganisms. But before the origin of life they must have accumulated till the primitive oceans reached the consistency of hot dilute soup. Today an organism must trust to luck, skill, or strength to obtain its food. The first precursors of life found food available in considerable quantities for existence.

Few scientists were aware of this earlier statement of Haldane's until van Niel called attention to it,[5, 6] although, in the intervening years, at least one elementary textbook[7] gave the argument an adequate presentation. Van Niel has also pointed out that at least two other men[8, 9] arrived, apparently independently, at the same hypothesis.

Even Haldane's statement of the problem was not the first. More than half a century earlier, in a letter written in 1871, Charles Darwin, discussing the problem of spontaneous generation, said:

> It is often said that all the conditions for the first production of a living organism are now present, which could ever have been present. But if (and oh! what a big if!) we could conceive in some warm little pond, with all sorts of ammonia and phosphoric salts, light, heat, electricity, &c., present, that a proteine compound was chemically formed ready to undergo still more complex changes, at the present day such matter would be instantly devoured or absorbed, which would not have been the case before living creatures were formed.

This passage appears in a footnote (Vol. II, p. 202) of the two-volume edition of Darwin's *Life and Letters.*[10] Inasmuch as the index appears to have no citation whatever of this passage, it is scarcely surprising that it is not referred to by Haldane, Oparin, Horowitz, Dauvillier and Desguin, or Beutner.

Perhaps similar statements have been made by others, and lost sight of. In a certain sense it may be said that there are historical truths that are trivial. If one is interested in the history of the development of America, Columbus matters, and Leif Ericson does not. In this sense, the statement of Darwin is unimportant. Yet from a humanistic point of view it is surely of interest that here is but another phase of biology that Darwin's remarkable intellect illuminated, even though evanescently. Moreover, from a thoroughly practical standpoint it is surely significant that there are so many Leif Ericsons in science, so many ideas clearly expressed and then forgotten. Not many recorded facts are lost; the bibliographic apparatus of science is fairly equal to the problem of recording melting points, indices of refraction, etc., in such a way that they can be recalled when needed. Ideas, more subtle and more diffusely expressed, present a bibliographic problem to which there is no present solution.

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Zinc Deficiency of Plants in the Western States*

F. B. WANN and D. W. THORNE

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THE basic foundations of the science of plant nutrition were laid nearly one hundred years ago in Germany by the experiments of Liebig, Sachs, Pfeffer, and others. One of the results of these studies was the development of the concept of a limited number of "essential chemical elements" in nutrition as opposed to the idea that all the thirty or more elements found in the ash of plants must be of value in growth. When ten of these "essential elements" were supplied to plants in solution culture, normal growth occurred, but a lack of any one of the elements resulted in abnormal plants with deficiency symptoms that were more or less distinctive for each of the elements involved. Thus the symptoms, expressed chiefly in the leaves, of a deficiency of nitrogen, potassium, phosphorus, magnesium, sulfur, calcium, or iron have long been recognized. The three remaining elements, carbon, hydrogen, and oxygen, which were supplied the plants by the CO_2 of the atmosphere and by water, were never deficient in these solution-culture experiments.

Refinements in the techniques of growing plants in solution culture during the past quarter century have demonstrated that a number of other chemical elements also must be regarded as essential. These include zinc, boron, manganese, and copper. Since these are required in such small amounts for normal growth, they are spoken of as "trace elements," "micronutrient elements," or "minor elements." Minor element deficiencies also result in nutritional disease symptoms that are characteristic for each of the elements. Thus, in the absence of zinc, older leaves are marked with a distinctive chlorotic mottling; young leaves are small, narrow, and crinkled, as well as being mottled; terminal growth is much reduced, and in advanced stages rosettelike clusters of small, narrow leaves develop at the tips of the branches.

For many years prior to the demonstration of the essentiality of zinc in plant nutrition, the fruit and nut industries of the South and West were seriously concerned with a number of "little leaf" and "rosette" diseases, the causes of which were obscure. The failure of early observations to associate pathogenic organisms consistently with any one of them suggested that the disorders were probably nutritional in origin, and attention was therefore directed to a study of the plant-soil relations. Although experiments performed during the first quarter of the century gave some measure of control of rosette, the exact nature of these diseases remained as baffling as ever. About 1928, extensive experiments on the relation of zinc to little leaf were initiated, and within the next few years workers in several states demonstrated the effectiveness of this element in combating both rosette and little leaf.

Zinc-Deficiency Symptoms

Pecan rosette. The chief symptom of this disease is, as the name implies, the production of rosettes of small leaves clustered together on much shortened branches. In older leaves the yellowish mottled areas may finally develop into dark reddish-brown or necrotic spots, or the failure of the interveinal tissue to develop properly may result in numerous smooth-margined holes over the leaf blade. Death of the tree rarely results. The disease may occur on trees of any stage of development, from seedlings to long-established mature trees.

Rosette of pecan was reported from many areas of the Southeastern and Southern states in the

* Published by permission of the Utah State Agricultural Experiment Station.

early part of the century. It was the first of the zinc-deficiency diseases to receive intensive investigation. Although regarded at one time or another as a soil nutrient problem, a virus disease, or an iron-deficiency chlorosis, the real nature of the disease was established in the period 1932–36 when several workers[1, 2] reported on the effectiveness of zinc salts in the control of rosette. The disease is now treated successfully by dormant zinc sprays or by soil treatments with zinc sulfate.

Apple rosette. The distinctive feature of this disease is the production of dense clusters of small, narrow, yellowish leaves at the ends of twigs that are bare of normal lateral leaves. The internodes are much shortened, so that a stem an inch or more in length may bear as many leaves as a normal 18-inch twig. The leaves are narrow, and the blades yellowish-green to yellow in color.

Apple rosette was reported in California in 1901, in Colorado in 1902, and in Idaho in 1904. Although early workers thought the disease was caused by unfavorable water relations,[3] it was demonstrated in 1934 that zinc injections resulted in recovery of rosetted trees in Washington. Subsequent work established the cause of this disease as zinc deficiency.

Little leaf. The production of small, strap-shaped chlorotic leaves is characteristic of little leaf. The chlorotic mottling progresses inward from the margin, invading completely the areas between the lateral veins, which remain green. The condition can be distinguished from iron chlorosis because in the latter disease the small network of veins between the laterals retains the green color. In more severe stages of little leaf, considerable dieback occurs, particularly in sweet cherries, and in peach and apricot a rosetted condition is common (Figs. 1, 2).

Little leaf of stone fruits was reported in California as early as 1911, and a similar condition in grapes was described in 1917. The first serious attack on the little-leaf problem was initiated in 1928 by the California Agricultural Experiment Station, and the results of the experiments were reported in a series of papers by Chandler, Hoagland, and Hibbard[4, 5, 6] beginning in 1931 and extending through 1936. The effectiveness of zinc in controlling the disease was definitely established.

Mottle leaf of citrus. In this disorder the leaves develop irregular chlorotic areas located between the lateral veins. Portions surrounding the midrib and lateral veins remain green; the result is an irregular spotting or mottling. The leaves may be normal in size in the first stages of the disease, but subsequent crops of leaves become smaller, and in severe cases they may be extremely narrow. Dieback may follow, ultimately resulting in death.

Citrus mottle leaf responds favorably to various zinc sprays and dusts,[7] indicating that it, too, is a zinc deficiency.

Distribution of Zinc Deficiency

Chandler[8] reports "all orchard and ornamental trees and shrubs growing in the valleys of California seem to show injury if the zinc deficiency is great enough, but the differences in susceptibility are large." He lists sweet cherry, apple, and pecan as most susceptible. Other plants affected include Japanese plum, peach, European plum, pear, walnut, apricot, avocado, citrus fruits, almond, and some varieties of grape and fig. Relatively few herbaceous plants growing in natural habitats have been observed to suffer from a lack of zinc, though many such plants have developed zinc-deficiency symptoms in controlled solution culture. According to C. E. Scott,[9] one case of deficiency on beans in a corral spot in California has been established, and

FIG. 1. Zinc deficiency on sweet cherry, showing severe dieback condition. Leaves are small and chlorotic.

there are several suspected cases on cotton in the San Joaquin Valley. In Oregon, Powers and Pang[10] report that beans, corn, potatoes, sunflowers, tomatoes, and cane fruits on Powell silt loam soils have responded to zinc applications.

The distribution of zinc deficiency in the eleven Western states and adjoining provinces of Canada is shown in Figure 3. In the coastal states, it will be observed that the deficiency is confined almost entirely to irrigated valleys of the interior. A few scattered areas, particularly in California, are associated with old corral spots. In the Intermountain states, the deficient areas are in irrigated valleys along the slopes of the Rockies and along the lower reaches of the Snake River in Idaho. In New Mexico and Arizona pecan rosette occurs in practically all the regions where this nut is grown. In Colorado zinc deficiency has been observed in only one area on the western slope of the Rockies. No distribution data are available for Nevada, Montana, and Wyoming, but it is probable that apple rosette occurs in these states, especially in Montana.

Zinc deficiencies in the Western states occur predominantly on either sandy soils or soils previously treated with large quantities of organic matter. The latter group includes sites of old corrals and stockyards.

In studies in Utah[11] sandy soils on which zinc deficiency occurred were generally low in lime and contained only about half as much total zinc as nearby calcareous loam soils. The parent rocks from which soils of zinc-deficient areas were derived, however, were found to contain about the same content of zinc as samples of limestone rock and other soil parent materials. Undoubtedly during weather processes the siliceous rocks and sandy soil materials are leached of zinc more rapidly than the more basic rocks of the finer-textured soil materials.

No intensive study has been reported on the cause of zinc deficiency on old corral spots and related areas. Chandler, Hoagland, and Hibbard[5] postulate that organic matter in these spots has a high capacity to fix zinc in forms of low availability. They also point out that these spots are high in nitrogen and that high nitrogen conditions accentuate little-leaf injury.

Hibbard[12] has shown that it is natural for zinc to be taken up by plant roots, to be translocated to leaves, and, as the leaves fall and decay, to have the zinc fixed in the topsoil. Thus, the subsoil is gradually depleted of zinc and the topsoil enriched. This probably is one important reason why deep-rooted perennial plants show zinc-deficiency symptoms more commonly than annuals.

High available soil phosphorus, or phosphate fertilizers, have also been shown to be capable of precipitating zinc and inducing deficiency symptoms.[13] Evidence has been obtained recently that this may be an important factor in zinc deficiency in Utah.

Economic Importance of Zinc Deficiencies

It is impossible to give an accurate estimate of the losses caused by zinc deficiencies—chiefly because the distribution is frequently localized, affecting only a few trees in an orchard. On the other hand, where the disease is more serious, it is being effectively controlled by the use of zinc. One approach would be to estimate the acreage that would be seriously affected if zinc were not applied and determine the potential crop losses on this acreage. This was done in California by E. F. Serr and A. D. Rizzi,[9] with the following results: (1) Estimated total acreage affected enough to reduce the crop value 50 per cent if no zinc were applied—230,400 acres; (2) estimate of crop losses if no zinc were applied—$33,886,250.

In another approach to the problem, Serr and Rizzi show that spraying 230,400 acres at an average cost of $6.00 per acre would mean an annual outlay of $1,382,400 for the control of zinc deficiency in fruit and nut trees in California.

In Oregon it is reported[10] that soil types in that state now known to respond to zinc include approximately 100,000 acres. In Washington and Idaho about 1 per cent of the fruit trees is affected. The cost of spraying is the chief economic factor. Surveys conducted in Utah in 1948 and 1949 revealed that about 7 per cent of the orchards or plantings contained trees showing zinc-deficiency symptoms. No estimate of the economic importance of zinc deficiency in Arizona was obtained. Pecan rosette is apparently controlled there effectively by zinc treatments. Elsewhere in the Western states zinc deficiency is of minor significance.

Treatment of Zinc Deficiencies

Little leaf and rosette. In California, Scott[14] reports all the stone fruits except cherry are treated satisfactorily by dormant applications of zinc sulfate as a spray. Dormant sprays are sometimes supplemented by foliage sprays. Spur-pruned grapevines are treated by daubing the freshly cut pruning wound with a solution of 1.5 pounds of zinc per gallon, and cherry and walnut are treated by driving zinc-coated pieces of galvanized iron into the trunks and main limbs.

In The Dalles area of Oregon a zinc spray of 50 pounds per 100 gallons applied in the dormant

FIG. 2. Typical rosette and dieback in peach with zinc deficiency.

condition gives satisfactory control in cherries.[15] This may be supplemented by a foliar spray using 18 pounds of zinc sulfate and 6 pounds of hydrated lime per 100 gallons. Zinc tacks or zinc injections has been necessary for recovery.

In Idaho and Utah dormant sprays of 25–50 pounds of zinc sulfate per 100 gallons are in general use.

Arizona is the only state where soil treatments with zinc sulfate are recommended, though in some instances as much as 25 pounds per tree has been necessary for recovery.

Citrus mottle leaf. Chapman, Brown, and Rayner[16] recommend spraying with 5 pounds of zinc sulfate and one half as much lime hydrate or soda ash per 100 gallons; lime sulfur can be used in place of lime hydrate or soda ash as a precipitant. High-grade zinc oxide at a rate of 1.3 pounds per 100 gallons also gives satisfactory results. Spreaders are unnecessary. Zinc dusts are not as effective as sprays. Sprays should be applied prior to the spring or fall growth cycles.

Zinc oxide may be combined with oil sprays (when recommended by the manufacturer), with nicotine sulfate sprays, or with sulfur or cryolite dusts. A zinc, copper, Bordeaux formula considered safe where fumigation is practiced consists of copper sulfate 1 pound, zinc sulfate 5 pounds, hydrated lime 4 pounds, per 100 gallons. Soil treatments have not been satisfactory.

Function of Zinc in Plant Nutrition

Thatcher[17] in a discussion of the relation of the periodic classification of mineral elements and their roles in plant nutrition grouped zinc and copper together as a pair of coordinated catalysts in oxidation-reduction phenomena. He suggested that they were concerned in reactions involving the transfer of hydrogen. Since, however, zinc cannot change valence values, participation in oxidation reactions is probably indirect. Skoog[18] found that tomato plants grown in zinc-deficient cultures failed to elongate and that the auxin content was extremely low. Visible symptoms of zinc deficiency appeared only after decrease in auxin. Addition of zinc to the cultures resulted in an immediate increase of auxin in the plants and the initiation of normal growth a few days later. The low-zinc plants with low auxin content had an exceptionally high peroxidase activity. Skoog suggested that the increased peroxidase activity in zinc-deficient plants caused the destruction of the auxin.

Reed and Dufrenoy[19] have presented cytological evidence that in zinc deficiency in deciduous trees the oxidation-reduction equilibrium is upset, many chloroplasts are destroyed, and phenolic substances accumulate in the vacuoles. Bean[20] showed that low zinc impaired protein and starch synthesis in tomatoes, and, on the basis of these results, Hoagland[21] postulated that zinc is a component of a catalytic system necessary for the phosphorylation of glucose or an amino acid.

It is apparent that zinc deficiencies occur in serious proportions in all the major fruit- and nut-producing areas of the Western states. The actual losses in crops and trees are not now of great economic importance because the diseases are readily recognized and are being successfully controlled by zinc applications. A dormant spray of zinc sulfate is the most common control measure. Since this must be repeated each year, however, the total cost of maintaining trees in healthy condition in the zinc-deficiency areas is of economic significance. In California it is estimated that this cost amounts to nearly one and a half million dollars yearly.

There is some evidence indicating that the deeper soil strata under orchard trees are being gradually depleted of available zinc. If this is true, it is probable that the distribution of zinc deficiencies will be considerably extended in the years to come, and the numerous cases of mild deficiency symptoms scattered throughout all the major fruit areas of Utah would seem to substantiate this.

Several references in the literature to cases of combined zinc and manganese deficiencies in the same tree introduce a conflicting factor into the diagnosis of zinc deficiency, and the diagnostic picture may be clouded further by iron chlorosis and numerous virus diseases. Careful studies will be required to differentiate all these factors in the field. Growers should be urged to become familiar with the symptoms of zinc deficiency in order that proper control measures can be initiated while the diseases are still in the mild stage.

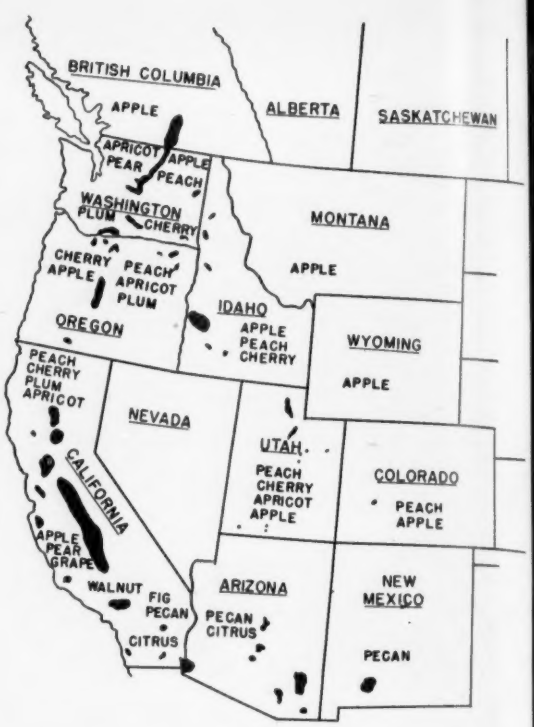

FIG. 3. Map of western United States and Canada showing distribution of zinc-deficient areas and crops affected.

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Coffee, the "Exotick Drug"

MARIE-LOUISE and JEAN DUFRENOY

Dr. Marie-Louise Dufrenoy (Ph.D., University of California, Berkeley, 1942) has been teaching in the French Department of her alma mater since 1937. She is the author of L'Orient Romanesque en France. *Dr. Jean Dufrenoy (Docteur ès Sciences, Sorbonne, 1925) is at present engaged in research on antibiotics at the College of Pharmacy of the University of California at San Francisco. In collaboration with Dr. R. Pratt he has just written a book entitled* Antibiotics.

FOR ten centuries Christian civilization developed north of the Mediterranean Sea in a world encompassed by "The Ocean" and the Near East. Mohammedism had erected in the Near East a steel curtain that shrouded in mystery the lands beyond, the lands from which valuable spices could be obtained. Columbus had been foiled by the encounter of America in his attempt to by-pass the Moslem barrier westward, but Vasco da Gama succeeded, by sailing along Africa, in by-passing the Land of Coffee to reach the Land of Tea. Thereafter, Portuguese, Dutch, English, and French competed on the maritime route, to develop their trade behind the Moslem curtain.

Few attempted to lift the curtain; fewer still were admitted into the Turkish Empire, where the ban on alcoholic beverages had been lifted about the sixteenth century by the adoption of the Arabian drink *kahoueh,* pronounced by the Turks *qahveh,* and by travelers rendered variously as *kauve* or *cauve,* from which there eventually evolved the French *café,* the English "coffee."

Coffee was first brought to the attention of European scholars by Rauwolf in his *Eigentliche beschreibung der Raisz so er vor diser zeit, gegen auffgang inn die morgenlaender vollbracht,* published in Laugingen in 1582–83. Soon thereafter, Prosperi Alpini described the coffee tree in his *De Planto Aegypti,* published in Venice (1592). Alpini grew some coffee trees in the Botanical Garden at Padua, and in 1596 the Italian botanist Onorio Belli could send to his friend Charles de l'Ecluse some "of those seeds which the Egyptians use to prepare a liquid which they call cave."

Following closely on the trail blazed by Rauwolf and Alpini, a number of travelers reported their experiences in quest of coffee or other exotic products: Parry, commenting on Sir Anthony Sperley's *Voyage to Persia* (1599); Captain John Smith, telling of his *Travels and Adventures* (1603); Purchas telling of *His Pilgrimes* (1607); Biddulph, reporting on *The Travels of Certayne Englishmen in Africa . . . Asia . . . etc. Begunne in 1600 and by certain of them finished this yeere 1608;* Sir Thomas Herbert's *Relation of some yeares travaile begunne anno 1626 into Afrique and the greater Asia;* Rolamb's *Relation of a Journey to Constantinople* in 1657; Olearius' *Account of his Journeys;* Thévenot's *Voyages . . .* , published by Luisandre and Pétis de la Croix; Bernier's *Voyages . . .* , published in Amsterdam (1600); and, last but not least, Jean de la Roque's *Voyage to Arabia the Happy.*

The Coffee Trade

François Bernier had failed in his attempt to visit Arabia the Happy, from which, he knew, the whole of Turkey obtained *cauve,* the usual drink of the Turks; he even had to give up all hope of visiting Ethiopia or Abyssinia, the birthplace of *Coffea arabica,* grown in Arabia. Instead, he proceeded eastward, eventually becoming the Physician to the Court of the Great Mogul; there for twelve years he initiated Eastern scholars into Western science, even into the mysteries of the circulation of the blood, which had recently been unraveled by Harvey and so hotly disputed in Europe. (Harvey should be remembered not only as the great physiologist, but also as the great lover of coffee, who on his deathbed, in 1657, bequeathed to the Royal Society the greatest treasure in his laboratory—fifty-six pounds of coffee purchased at high cost from Venetian merchants.)

Forty years after Harvey's death, coffee was still rare in Europe; in 1696 *Le Mercure Galant* reported that "Coffee is harvested in the neighborhood of Mecca; thence it is shipped to Suez, and transported by camels to Alexandria, where, in Egyptian warehouses, French and Venetian merchants buy the coffee-beans they need." A few years later, the Dutch had snatched away most of the coffee trade from the Egyptians. Disproving the

allegation that coffee beans, previous to export from Arabia, had been heated or dried so they could not germinate, Nicolas Wisen, of Amsterdam, germinated coffee beans in Batavia and started the coffee industry of the Dutch Indies.

Introduction of Coffee into the Americas

About 1710 Jean de la Roque, with two French ships, having completed his voyage into the Red Sea, sailed back by way of Bourbon Island (now Réunion), carrying along some *Coffea arabica,* which the inhabitants immediately recognized as akin to shrubs growing in the mountainous parts of the island. That discovery of what is now known as *Coffea borbonica* (or *C. mauritiana*) was joyfully acknowledged in the *Histoire de l'Académie Royale des Sciences* (1716), "since it would be advantageous for the Realm to obtain from a French possession a berry enjoying so much favor." No attempt was made to develop that advantage in the French islands of the Indian Ocean.

At that time, however, the similarities between the East and the West Indies as to climatic conditions and natural vegetation had been recognized by Declieux, who surmised that the French could acclimatize coffee in the Antilles as successfully as the Dutch had developed it in their East Indies possessions. In 1723, Declieux sailed to La Martinique with a rooted cutting from the coffee plant presented to Louis XIV by the mayor of Amsterdam in 1714 and grown in the King's hothouses. From that transplant there originated all the seedlings planted throughout the Antilles; already in 1726 Father Labat was able to report that two hundred coffee plants were bearing fruit in La Martinique, and in 1774 Declieux wrote to Fréron, the editor of *L'Année Littéraire,* "the culture of Coffee is spreading . . . in course of time Guadeloupe and San Domingo discovered the fruitful shrub. . . ."

In 1722, M. de la Motte-Aigron planted twelve hundred coffee trees at Cayenne; seeds from those trees were soon introduced into Brazil, starting the coffee industry in that country; moreover, in 1743 Furna Uchoa brought back with him to Brazil some cuttings that had been donated to him by Louis XV —from those same coffee trees that had yielded the cuttings imported into the Antilles.

Coffee harvest. Girl pickers select the ripe red "cherries," leaving the immature green ones on the tree for later harvesting, at the Hacienda Curridabat near Tres Rios, Costa Rica. (USDA-FAR photo.)

The Literary Vogue of Coffee

The French reading public had been introduced to Turkish coffee first by J. de la Roque on his return from Constantinople, where he had accompanied the French ambassador; and more effectively still by Soliman Aga, whom Mohammed IV had sent as his ambassador to Louis XIV in 1669 and 1670. In 1671 Dufour published his *Treatise concerning the Use of Coffee, Tea and Chocolate* in the form of a *Dialogue between a Physician, an Indian and a Gentleman.* In 1699, the same year that François Bernier published the book relating his experiences in the Land of Coffee and the lands beyond, Antoine Galland published the translation of the oldest manuscript pertaining to the history of coffee. A few years later Galland's translation of the *Arabian Nights* catalyzed the trend of Oriental novels into its curve of growth.

In 1718 Jussieu, reporting before the Académie Royale des Sciences on the coffee plant and its history, recalled the Oriental legend according to which goats, manifesting excessive activity and wakefulness after browsing on certain shrubs, called the attention of a monk to the berries of the shrubs, from which he concocted the brew that would help his brothers to keep awake during the long night prayers.

Coffee drinking, as it developed in Western Europe, was considered a most undesirable "fad" by Madame de Sèvigné, who was interested in anything bearing on medicine, kept closely in touch

with the medical celebrities of her day, and assumed competence in the field of medicine, even to the point of considering herself an M.D. in *honoris causa*. Conversely, the use of coffee was welcomed by those who saw in the new drink a substitute for the alcoholic beverages so much in favor in northwestern Europe: coffee was heralded as the "pure intellectual stimulant," which, unlike alcohol, would not stir sexual impulses. In his Oriental tale entitled *Angola,* La Morlière featured the woes of the lover who had become so bewitched that he succumbed to slumber as soon as he came near his sweetheart; the young couple had to travel all the way to Arabia to visit the magician Moka, who brewed a mysterious liquor endowed with the virtue of overcoming any tendency to doze.

In 1746, when La Morlière humorously romanticized the "eternal wakefulness" of him who drank the magic obtained from Moka, the vogue of Oriental tales was about to wane; however, many scientific facts, which had been presented to the French reading public in the garb of an Oriental tale during the first half of the eighteenth century were, during the second half of the century, matters for investigation by the newly developed sciences such as chemistry; the physiological properties of coffee became one of these matters.

Physiological Properties

Coffee, in the early days of the seventeenth century, was sold as a medicine, "the first steps it made from the cabinets of the curious as an exotick seed, having been into the apothecaries' shops as a drug." "Coffee is commended against Contagion," we read in Gideon Harvey's *Advice against the Plague,* published in 1665. But, from the time in 1660 when Paulli denounced the abuse of the newly imported drugs and drinks, to 1788, when Tudesq credited coffee with the same virtue that had made quinquina famous for the treatment of malaria, coffee had been a topic for academic discussion rather than for experimental studies.

The year 1788 marked the important date when Tudesq focused attention on a property common to the extracts of *Coffea* and *Cinchona,* two members of the Rubiaceae family. At that time several chemists had already narrowly missed the discovery of quinine; in 1746 Claude de la Garaye had crystallized *sel essentiel de quinquina* from cinchona bark, and about 1788 Vauquelin started some researches that he did not complete, although he believed that they would lead "to the discovery of an anti-periodic febrifuge, which once known, may be extracted from various plants." In 1811 Grindel advocated green coffee as a substitute for quinquina, and as an antiseptic, and that same year the Academy of Toulouse offered a prize for the discovery of quinine or of an indigenous source of coffee.

Working on the assumption that, since Coffea belongs in the same family of plants as Cinchona it ought to yield quinine, Robiquet isolated caffeine, which simultaneously and independently was discovered by Runge, in Germany, and, in France, by Joseph Pelletier and Joseph Caventou; the last two chemists had also in 1820 discovered quinine, for which achievement they were awarded the Prix Monthyon of 10,000 francs, the only reward they received for their work.

The three drinks which Dufour had already compared in his treatise published in 1671 were, a century and a half later, recognized as embodying relative xanthine derivatives: namely, the 1,3,7-trimethyl xanthine, or caffeine; the 1,3-dimethyl xanthine, or theophylline; and the 3,7-dimethyl xanthine, or theobromine. As soon as the common structure of the active principles had been determined by chemists, physiologists began experimenting with coffee, tea, and chocolate. In 1867 Leven brought under the test of experiments on frogs Bacon's statement in 1624 that "the Drink comforteth the Brain and the Heart;" and Rabuteau concluded in 1870, from experiments carried out on himself, that Bacon had also been right when he wrote of coffee "it helpeth Digestion." That caffeine favors the utilization of nitrogenous materials from food, and exerts a "sparing action" due to diminished urea excretion, have been confirmed by recent research, which further demonstrated that caffeine enjoys the unique property, among drugs, of increasing work output in man, even though the increase in amount of work be achieved at the expense of accuracy.

Neither alcohol, nor cocaine, nor nitroglycerine, used for "doping" in competitive sports, has been demonstrated to increase the ability of normal, nonfatigued athletes to perform maximal muscular work in controlled experiments, lasting either fifteen seconds or five minutes; caffeine itself proved ineffective in such short experiments. Conversely, it may stimulate the organism to overcome the inhibitory effect of fatigue in long-lasting efforts. In the words of Bacon, caffeine "comforteth the Brain." Caffeine, indeed, exerts action on cholinesterase, the enzyme that plays a prominent role in brain tissue; it also affects the pseudo-cholinesterase in the blood serum, but, in contrast with other drugs, which, if they affect cholinesterases, also affect other esterases, the effect of caffeine is restricted to the cholinesterases.

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photo.)

The effect of coffee on man or animals is ascribable to various constituents besides caffeine, notably caffeic acid, essential oils, and various vitamins, particularly nicotinic acid.

Caffeic Acid

The changes induced in the coffee bean by roasting attracted attention long before they could be chemically explained; for more than a century chemists had suspected the coffee bean of containing tanninlike substances, variously named "cafique," "cafetannic," etc. It is now recognized that the coffee bean contains a complex of caffeine and caffeic acid. Many plants besides Coffea biosynthesize caffeic acid, a 3,4-dihydroxycinnamic acid, which, like other orthodiphenols, may yield quinonic derivatives endowed with antibiotic properties; for instance, caffeic acid, as present in the pulp of the tomato, accounts in part for the failure of the seeds to germinate unless they have been carefully washed; likewise, caffeic acid, whether isolated from plant tissues or synthesized in the laboratory, prevents the growth of various microorganisms in culture media which contain neither peptones nor proteins. Caffeic acid and its derivative, hydrocaffeic acid, have recently achieved prominence in the food industry as antioxidants.

The most important modern event in the history of coffee was the discovery by Auguste Chevalier of a new species of Coffea in the *forêts-galeries* of the high plateaus of the Chari, in western Africa. This new species, *C. robusta* Chevalier, was soon to assume an immense economic importance, since it proved to be resistant to the rust disease caused by a fungus, which wiped out the original plantations of *C. arabica* in many parts of the East Indies.

Western civilization was introduced to Turkish coffee three centuries ago; the introduction of coffee at the court of Louis XIV "markedly influenced the development of the *'Grand Siècle.'*" Almost immediately the demand for more coffee than could be obtained from Arabia resulted in the cultivation of *C. arabica* in the East Indies, then in the West Indies, in Cayenne, and in Brazil. By the second half of the eighteenth century, enough coffee was available to stimulate the intellectual activity of the Philosophers, who paved the way for the War of Independence and the French Revolution.

Today, of the five billion coffee trees under cultivation across the Seven Seas, more than four billion grow in South America, but not even one in a thousand grows in Asia, which two hundred and fifty years ago supplied the whole world with coffee.

Ion Exchange

F. C. NACHOD

Dr. Nachod (D.Sc., Utrecht) was born in Leipzig and educated at the universities of Paris, Freiburg, Leipzig, and Utrecht. He has taught at Utrecht, City College (N. Y.), and at Columbia and has had considerable industrial experience in ion exchange and its applications. He is at present in charge of physical chemistry at the Sterling-Winthrop Research Institute, where he has been on the staff for the past three years. His review is based on a discussion on the General Electric Company's Science Forum over Station WGY, Schenectady, and on an address before the ACS student affiliate chapter at Rensselaer Polytechnic Institute last October.

ALTHOUGH it has been known for almost a hundred years, the ion exchange process was not in common use until a few decades ago. Many unit processes, such as distillation and filtration, were known to the alchemist, but here is a stepchild long neglected now coming into its own. It should be interesting to see how it happened. Perhaps we should first define ion exchange and then attempt to go into its ramified applications. Ion exchange is the reversible interchange of ions furnished from the solution with ions present in a solid matrix of the exchanger without any other significant concomitant changes. In this respect the reaction might remind us of a game of musical chairs or of puss in the corner played in the microscopical dimension of the angstrom.

The discovery of this ionic game goes back to two English soil scientists, Way and Thompson, who were wondering what made water-soluble fertilizers work as nutrients. Why, they asked, should the potassium and ammonium ions become available to plants if placed on top of the soil, instead of percolating right through? They investigated this in simple model experiments, using columns of earth and general analytical techniques, and so discovered the phenomenon that was to be known as base exchange.

No commercial applications resulted from their discovery until the German chemist Gans came along in 1910 and found that certain minerals—the zeolites—could be employed to soften hard water or, in our parlance, to act as ion exchangers for the removal of calcium and magnesium ions for sodium ions. Gans found that he could produce synthetic materials which gave high capacities, but, when it came to an interchange with hydrogen ions, his aluminosilicates did not have enough physical resistance to do the job. The most significant advances came in 1935 when two English investigators, Adams and Holmes, found that certain organic resins can undergo ion exchange reactions. One of the materials was the result of reacting phenolsulfonic acids with formaldehyde, which yielded a bakelite-type resin that, though solid, behaved as a strong acid. Figure 1 shows a more recent cation exchange material. We may visualize it as a hydrogen ion sponge in which the ions are statistically spaced in a three-dimensional network. A different category of materials, the anion exchangers, was the result of condensation of polyamines with aldehydes. This reaction produced a "solid base," a more recent version of which is depicted in Figure 2. The two types of ion exchange materials opened up new horizons: it should be possible to remove all dissolved salts from water by a successive two-step treatment. This is indeed the case.

Paradoxical as it may sound, it now became possible to produce water of distilled-water quality without distillation. Let us examine how it is done: the water is percolated through a tank containing the cation exchange resin in the hydrogen condition. All cations are "swapped" for hydrogen ions, and effluent from this unit is acidic. It is now passed over the anion exchanger, which removes the acid, and the resultant effluent is neutral water from which all ions, both cationic and anionic species, have been abstracted. The economics of this process are self-evident: the "distilled" water is produced at a fraction of the cost necessary to achieve the same goal by conventional means. After the units are exhausted, they are regenerated with acid and alkali, respectively, and the next cycle of operations is then started.

I

In order to understand the process somewhat better, we shall have to ask ourselves how these materials react. We have already learned that the process is reversible; i.e., that we can replace ion A with B or ion B with A. The general rules are those of the law of mass action, in the language of the chemist. This law does not describe the process completely, however, and other approaches to calculate equilibrium reactions and to predict exchanges have been carried out by employing exponential relationships called "adsorption isotherms." Species of ions play a considerable part. Thus a divalent cation, all conditions being equal, will replace a monovalent cation from the exchanger with greater ease than in the case of the reverse exchange, and it will be "bound" to the exchanger with greater force. If we consider similar cations, the position of the element in the periodic system and the concomitant hydration effects will play a role, so that, for example, rubidium ion will be bound stronger than sodium ion.

All ion exchange processes are extremely rapid. They follow generally well-known kinetic laws, but the mathematical treatment of reaction rates becomes quite cumbersome and difficult in these heterogeneous systems. (Readers may learn more of both theory and applications of ion exchange phenomena from a recently published monograph in this field: *Ion Exchange—Theory and Application.* F. C. Nachod, Ed. New York: Academic Press, 1949.)

The powerful nature of this tool of ion exchange may be better understood by pointing out generally what the process can do. It may be employed (1) in the removal of undesirable impurities, (2) in the concentration of desirable traces, (3) in the separation of closely related substances, (4) in the substitution of ions, and (5) in catalysis problems.

From this list it can easily be seen that the applications of the ion exchange principle must be manifold. Indeed, one might say that only the surface has been scratched. The water-conditioning industry is probably the largest single field of application, and perhaps it is because of this very fact that other applications have only lately come into being. In sugar refining we again meet ion exchange as a powerful method of increasing yield and purity of the product by removal of the so-called melassigenic salts.

One of the most dramatic and spectacular applications came out of the recent war, where it was imperative to produce drinking water from sea water for fliers marooned at sea. Conventional methods of distillation were impractical for single individuals on a one-man life raft, and a can of water would last just so long. Would it be possible to provide a multiple potential volume of drinkable water within the space of a single canister? Ion exchange gave the answer.

To accomplish the goal of removing 3.5 per cent of sodium chloride from sea water, one had to backtrack to the inorganic exchangers of Gans. If silver

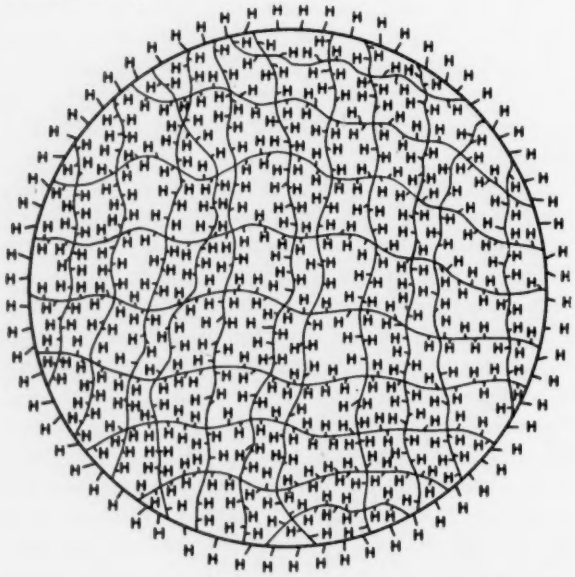


FIG. 1. Schematic structure of a cation exchange resin. From W. C. BAUMAN, "Fundamental Properties of Ion Exchange Resins, in NACHOD, *Ion Exchange,* 50. (Courtesy of Academic Press and ***J. Am. Chem. Soc.***)

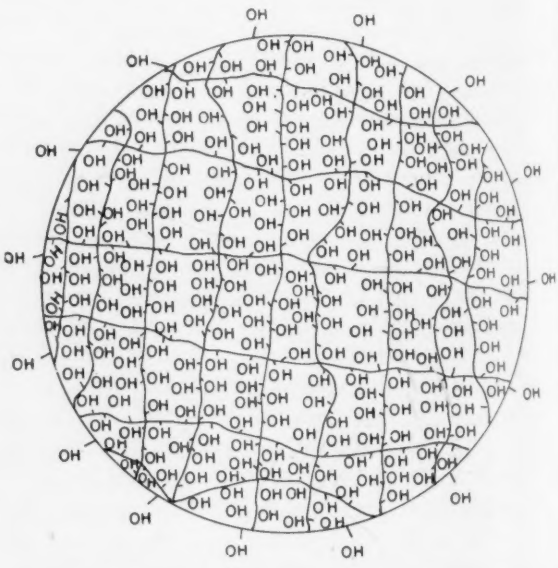


FIG. 2. Schematic structure of anion exchange resin. From W. C. BAUMAN, "Fundamental Properties of Ion Exchange Resins," in NACHOD, *Ion Exchange,* 67. (Courtesy of Academic Press.)

FIG. 3. Sea water desalting process. (Courtesy of The Permutit Company.)

Briquette of desalting chemical.

Briquette is dropped into plastic desalting bag filled with sea water to the marked line.

Hard briquette disrupts spontaneously. Water and chemical are thoroughly mixed by kneading.

After about an hour, clear water is sucked through filter at the bottom of the bag. Harmful salt has been removed by the chemical.

ions are placed into the alumino-silicate matrix and the material brought into contact with sodium chloride, the sodium ions exchange for the silver ions, the latter combining with the chloride anions to form insoluble silver chloride. Thus, both cations and anions have been removed by virtue of exchange and subsequent precipitation. Of course, other ions are also present in sea water, and the above picture is somewhat simplified. For example, the sulfate ions must be reduced, and for this purpose a certain amount of barium ion exchanger is also added; this releases barium ions in order to form the insoluble barium sulfate. Other refinements and corrections for alkalinity and taste are needed to make the process work. The over-all effect, however, is to provide nearly a 12 : 1 ratio of usable water over chemicals employed, thus resulting in a large potential amount of usable water. Figure 3 shows a series of operations to produce drinking water from sea water. The plastic bag in the lower picture was used to scoop up the sea water, and then a briquette containing the compressed exchange materials, sufficient in amount to treat the water, was added. A special "disrupter" in the briquette provided for breaking it up, and after a short time the water could be sucked through a filter plate at the bottom of the bag.

II

Let us now turn to the concentration of desirable materials. In many instances the presence of a desirable or economically useful substance is too low in concentration to warrant its recovery by conventional methods. Metal recovery may serve as a useful example. Copper wastes from the brass-pickling industries not only constitute an economic loss but also a nuisance as a disposal problem. Two ills can be remedied at the same time by passing the wastes over an ion exchange bed and by recovering a concentrated solution upon regeneration. Silver wastes in the photographic and motion-picture industries present a similar problem. We know now from O.P.B. reports that Germany's wartime economy was very waste-conscious, and tremendous efforts and large plants at the I. G. Farbenindustrie AG. were aimed at silver exchange recovery. Finally, if we turn to precious metals, we encounter another interesting angle, made possible by the high value of platinum, palladium, and the like. The precious metals form anionic complexes, such as chloroplatinate, and are firmly held by the anion exchange resin. Their high value permits the organic resin to be ignited and burned off after it has been exhausted, leaving behind the pure metal ready for powder metallurgical purposes or for further refining.

Not all the desirable ions need to be inorganic. Large organic compounds may be ionic under proper conditions. Here we may cite another interesting wartime application. Quinine, a compound present in the bark of the cinchona tree, is an antimalarial drug of great value. In the Dutch East Indies, barks run as high as 6–8 per cent of available alkaloids, and most processes are geared to such concentrations. On the other hand, South American trees yield only an average of 1–2 per cent, and conventional refining methods are impractical. In acid extracts, the quinine molecule forms a hydrogen ion complex, the quinonium ion, which readily enters into an exchange reaction. By using a somewhat more complicated regeneration system, alcoholic alkali, a complete recovery of the quinine alkaloids is effective. When in World War II the supply from the Dutch East Indies was cut off, it became necessary to focus attention on the South American supplies. Special field units were constructed, and Army Corps of Engineers teams went into the jungle and came back with the "Totaquine" concentrate.

III

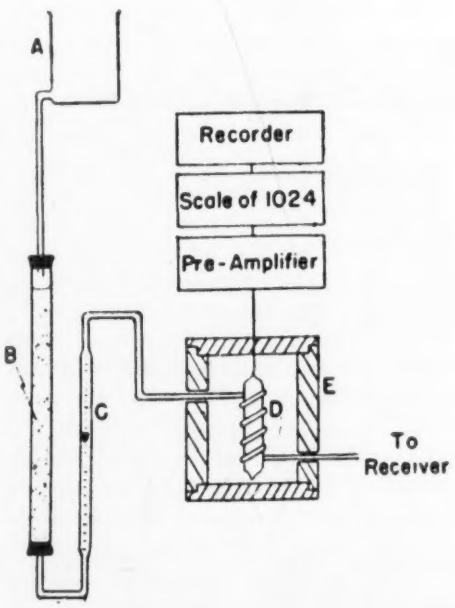
The next category in our list is the separation of closely related substances, and here, again, we have many facets of application. For example, the amino acids, the building blocks of proteins, are very similar in their chemical make-up. A broad classification divides them into the basic, or diamino, type, the neutral amino acids having one amino and one carboxyl group, and the dicarboxylic type. One can readily see that the first category should behave as cations, the second should be essentially nonionic owing to compensation effects, and the third should be anionic. This is indeed the case and permits ion exchange separation without any difficulty. The process does not stop here; further separations can be carried out, and they have even been done on a large scale. Another example of a complex system are the nucleic acids, adenylic, guanylic, cytidylic, and uridylic acids, which differ only very slightly in their chemical structure. Very elegant experimentation in the Oak Ridge National Laboratories resulted in separation and isolation, which had not been achieved hitherto.

Equally exciting work was performed in the inorganic field, and a review of this type would not be complete without at least a superficial discussion of it. I am referring to the separation of the rare earths, recently perfected in an unprecedented

manner. The elements, as has been stated, are quite similar in their chemical behavior. Separations usually were carried out, relying on slight differences in solubilities of their salts, by fractionized crystallization, which required many steps and yet yielded materials of only moderate purity. The new approach to the problem consisted of forming complex salts—e.g., citrates—and subjecting them to ion exchange column separations. Adding radioactive "tracers" served as a guide for separation efficiency. Additional benefits resulted from using elevated temperatures. Figures 4 and 5 show the elegant experimental procedure. These methods were transposed to pilot-plant scale dimensions, and so it was possible for the first time to produce the rare earth salts in kilogram quantities, often in better than 99.9 per cent purity.

IV

The fourth category, substitution of one ion for another, comprises another striking example, namely, the curd modification in milk by ionic exchange. The milk of different mammals reacts in several ways with the gastric juice in the stomach, this being a result of variations in the digestive processes of different species. The digestive process in humans is 20 per cent gastric, in cows 80 per cent gastric; hence the curd of cow's milk is tough and leathery, the one from human milk fine and flocculent. As this is a direct sequel of the calcium-sodium ratio, a readjustment of the relative amounts by ion exchange should result in cow's milk resembling human milk. That this is a practical process may be indicated by the fact that twenty-four companies in this country are manu-



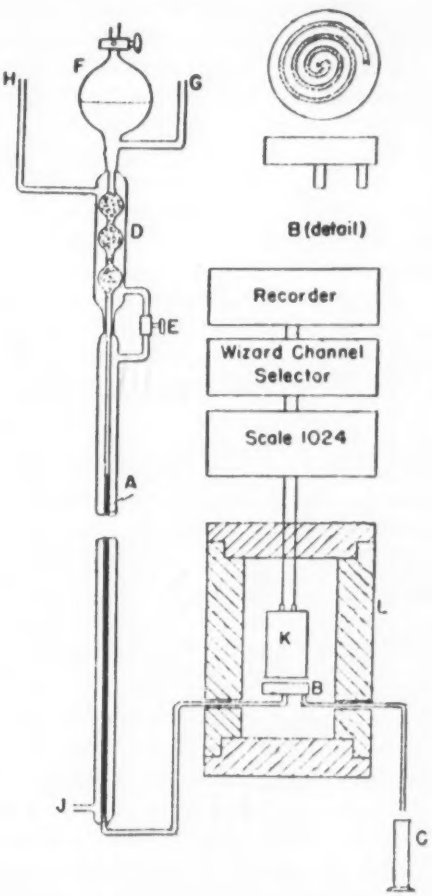


FIG. 4. Experimental arrangement for adsorption column studies: *A*, solution reservoir; *B*, adsorbent bed; *C*, flowmeter; *D*, Geiger-Müller counting tube; *E*, lead shield. From Boyd, *et al.*, *J. Am. Chem. Soc.*, 1949, **69**, 2,849.

FIG. 5. Experimental arrangement employed in adsorption column separations: *A*, adsorbent bed, Amberlite IR-1 or Dowex-50; *B*, counting cell; *C*, receiver; *D*, Allihn condenser; *E*, throttle valve; *F*, gas entrainment bulb; *G*, elutriant inlet; *H*, thermostat fluid inlet; *K*, mica end-window Geiger-Müller counting tube; *L*, two-inch lead radiation shield. From Ketelle and Boyd, *J. Am. Chem. Soc.*, 1949, **69**, 2,800, and J. Schubert in *Ion Exchange—Theory and Application:* New York: Academic Press.

facturing an improved milk product for infant feeding according to this process.

It would be impossible to discuss the applications of ion exchanges to catalysis extensively in an article of this type, and readers are referred again to the monograph (*op. cit.*). Suffice it to say that many of the inorganic catalysts employed by the petroleum industry are exchangers, and that their catalytic behavior can be correlated to their exchange character. Not only in cracking processes but also in desulfurization and sweetening have exchange materials found application. There is, however, one rather unique feature which should be further described. Some investigators have referred to it as the "tea-bag principle." A number of chemical reactions that are acid-catalyzed are sometimes also acid-sensitive when carried out in the presence of soluble strong acids. Certain esterifications or acetal syntheses fit in this group. By using a strong "solid" acid, it is possible to separate catalyst and reaction mixture, simply by decantation or by filtering off the acid catalyst before unwanted side reactions have spoiled the reaction yield.

Some additional interesting uses of ion exchange materials perhaps deserve mention. Anion exchangers have found application in ulcer therapy and have taken their place beside chemical antacids; relief of heartburn in pregnant women was observed following administration of anion exchange resins. Several recent publications have dealt with cation exchangers taken orally in the management of edema in hypertension. The underlying principle is the removal of sodium ions by substitution, since the depletion of sodium ions in the body is considered necessary in hypertensive patients.

It has been the purpose of this review to touch on some high lights that are the outcome of ramified research work during the past ten years. Here is a new unit process which, though old in principle, has only come into its own quite recently, and which will undoubtedly find many more novel applications in the years to come.

ITINERARY

THIRD INTERNATIONAL PHOTOGRAPHY-IN-SCIENCE SALON

University of Tennessee Knoxville	February 26–March 12
Cleveland Health Museum Cleveland, Ohio	March 16–31
Cranbrook Institute of Science Bloomfield Hills, Michigan	April 5–30
University of Nebraska Lincoln	May 6–20
University of California Berkeley	June 1–15
American Osteopathic Association Chicago	July 10–14
American Cyanamid Company Stamford, Connecticut	July 20–August 20
Battelle Memorial Institute Columbus, Ohio	September 22–30
Montana Society of Engineers Helena	October 10–17
Gamma Sigma Epsilon University of Florida Gainesville	November 6–13

Preventive Medicine

JOHN R. PAUL

The author, who received his M.D. at Johns Hopkins in 1919, has been on the staff of the Yale University Medical School since 1928 and professor of preventive medicine since 1940. His article is based on an address read before the Conference of Professors of Preventive Medicine in New York City, October 24.

WITHIN the past dozen years there has been discussion in medical schools and other medical organizations in this country as to where preventive medicine fits best into their general scheme of things.[1, 2] In some schools realignments have been drawn so that the preventive medical department could be placed within or in close apposition to those departments concerned with the clinical practice of medicine. In others, preventive medicine is regarded as a separate specialty. The issue is whether this approach to the medical care of people should be developed as an independent craft, or whether it should be cherished as one of the oldest of medical disciplines and part of the internist's or general practitioner's heritage.

There have been further discussions as to what name to apply to this medical discipline, in that the term "preventive medicine" leaves much to be desired,[3] and is actually no better than another somewhat boastful, but less familiar term, "curative medicine." Common usage of the term preventive medicine has increased, however, and this has today led to its wide acceptance in this country. Apparently *any* effort at present which aims at the prevention of disease is popularly called preventive medicine.

But such details of nomenclature and academic organization are not really important; what is important is whether preventive medicine deserves the fate of becoming a side line as far as physicians are concerned, or whether it should be a basic component of the medical scene, and one that lies near its central core. I favor the latter view. This does not imply that physicians should dominate the practice of preventive medicine, but it does imply that preventive medicine still falls well within the purview of those physicians who are trained for, and capable of accepting, this responsibility.

Of course it is recognized that besides being part of clinical (or comprehensive) medicine,[4] preventive medicine has numerous ramifications and actually touches a host of different human activities: house construction; housekeeping; dietetics; and environmental, industrial, personal, and mental hygiene, to mention but a few. It has political, legal, social, and even religious aspects, and in some medical schools the attempt has even been made to bring the departments of preventive medicine under the wing of a university division of social sciences. Consequently the task here becomes that of trying to keep our vision clear and trying to define the framework within which an academic department of preventive medicine might attempt to operate, with the realization that it is a philosophy rather than a technical craft with which we deal.

First of all, some differentiation should be made between the concept of preventive medicine as used here, and the whole field of hygiene and public health. Public health has been defined by Winslow as follows:

> Public Health is the science and the art of preventing disease, prolonging life, and promoting physical [and mental] health and efficiency through organized community efforts for the sanitation of the environment, the control of community infections, the education of the individual in principles of personal hygiene, the organization of medical and nursing service for the early diagnosis and preventive treatment of disease, and the development of the social machinery which will ensure to every individual in the community a standard of living adequate for the maintenance of health. [The words in brackets were added by Prof. C.-E. A. Winslow to his earlier definition, which appeared in *Science*, 1920, **51**, 23.]

In reviewing his definition it is important to point out that the objectives are reached through the medium of organized community effort and the development of social machinery rather than through the medium of the medical profession per se. Today the public health field is rapidly expanding in various directions. Some of these directions, such as those involving the public care of patients, fall directly within the physician's sphere of interest—the two fields overlap here. But, on the other hand, some of the expansion has taken

place along lines that the physician is reluctant to follow. An extreme contemporary vision of such expansion has been recently summarized by Mr. Oscar R. Ewing, with the statement that: "Health is everybody's business, and everybody must make it his business."[5] To this statement physicians cannot be indifferent, nor can medical schools. It demands that physicians define their places in a vigorous movement of expanding activities of many types pursued in the name of public health and preventive medicine. The questions here are: How far do physicians care to become identified with the administrative and political responsibilities essential for public health practices? With the organization of community effort? With the development of social machinery? And to what extent should physicians as a group identify themselves with the activities of the many ancillary groups so essential to the social welfare field?

A tendency on the part of the medical profession to stand aloof from these mundane things may reflect a "holier-than-thou" or a "wiser-than-thou" attitude; but it is fairer to say that it is based on the fact that the respective philosophies of the physician and of the health and the welfare officer differ. Such differences are not undesirable and imply no antagonism; quite the opposite, for one field complements the other. It is a question of different interests. Physicians are apt to be interested primarily in disease; many of them are sentimental pathologists at heart. Disease is the positive thing for physicians, and the absence of disease has a negative value. To the medical officer, primarily interested in the welfare of his people, health becomes the objective. Disease has negative values. Second, physicians are more at home when dealing with individuals and their troubles, in opposition to the health officer, who deals with groups. As a whole, clinicians are inclined to treat each individual somewhat differently, in contrast to the medical officer, representing municipal, state, or national government, who, in his official capacity, is perhaps called upon to treat all individuals of the same age group alike. The individual or clinical approach calls for the exercise of clinical judgment, which is the physician's most unique asset and which, like other types of judgment, requires special "attention power" and cannot be spread about too thinly. It is different from the type of judgment useful in carrying out administrative responsibilities, and in public education. On the other hand, there is no doubt that developments in certain areas of the public health field have proved, and will prove to to be, of great educational value to the medical profession; and there is also little doubt that individual doctors cannot carry out programs of disease prevention as efficiently as can health officers. These are but a few examples as to how the two fields complement each other.

Further attempts to define the physician's part in the academic picture of preventive medicine as it now exists will not be made here because the modern physician's functions are changing kaleidoscopically and because the many divergent views about this would carry us far afield. But one can inquire how the clinical concepts of preventive medicine can be best developed as an academic discipline in medical schools. It has seemed to us that one of the best academic approaches to this subject both in the classroom and the laboratory is primarily through the medium of clinical epidemiology or clinical endemiology. I do not wish to become enmeshed at this point in definitive discussions of what epidemiology is.[6] But it should be emphasized that in certain centers in this country the concept of epidemiology is no longer limited to the study of epidemics, or even to the study of infectious disease. Both epidemiology and endemiology, in the sense used here, are terms which today describe the ecology of human disease—the circumstances under which any disease or injury occurs, whether that disease be an infection, a chemical poisoning, a surgical condition such as an accident, or whether the circumstances be endogenous or exogenous; and whether the group involved be familial, domiciliary, occupational, or what not. All the ills to which the human flesh is heir could be said to have their epidemiology, or their ecology—or, to use a term frequently employed in England, their social pathology. This primary approach may be as fundamental an introduction to preventive medicine as autopsy pathology perhaps is for clinical medicine. For, if one is willing to study the circumstances under which a given disease occurs, one should be in a better position to prevent it, following the clinical principle that treatment logically follows diagnosis.

There is a timely element for this ecological approach to medicine in that during the past generation medical practice and clinical instruction in medical schools have become so dependent upon hospitals. Modern medicine, which has become more and more of a hospital activity, demands that the apprentice work of third- and fourth-year medical students be almost entirely concerned with sick people in a hospital bed, or "sick" people in the dispensary. These sick people are isolated "specimens." They are segregated from their environment, removed from the circumstances under which

they became ill, separated from their families, stripped even of their clothes; all of which is done so that a proper atmosphere may be created for diagnostic study and careful management on the physician's part, free from outside distractions. It may be trite to point out that these outside "distractions" are the very things which the modern doctor or the student interested in preventive medicine might study also. For, if one is to handle patients adequately, it is necessary to bring clinical judgment to bear, not only on the patient but also on the circumstances under which his illness arose. There is nothing particularly original about this. It is, and has long been, the heart and soul of family practice, but it has been gradually eliminated from hospital practice, where analytical techniques for the examination of the patient or of specimens from the patient have come to dominate that field of internal medicine. A plea for a return to this basic attitude may sound like a plea for a "dead" period in American medicine, such as the one which occurred in Germany at the beginning of the eighteenth century—a period with a poverty of observation and a wealth of speculation. Possibly so, but I would rather believe it to be a plea for a more comprehensive or integrative type of medicine than the analytical approach so popular in past decades. That American medicine needs something of this type has been expressed elsewhere.[7] To fill this gap more than one academic department of preventive medicine has been created.

And yet here one might well raise the question as to whether the need for relating the patient to his native environment and all its attendant circumstances has not been the very thing that has brought social service departments into being in most good hospitals and, I presume, in all teaching hospitals. Such departments have proved indispensable, but a point I wish to make is that the existence of a local department of social service in a teaching hospital does not relieve local, academic clinicians of their responsibilities regarding "extra-hospital medicine." Physicians cannot put the whole responsibility of social medicine in the hands of lay social workers.

It has been of importance in this development of academic and clinical concepts of preventive medicine to observe what has been happening in many medical schools throughout this country and in England during the past decade. A number of new departments of preventive medicine, and/or of social medicine and/or of hygiene have been created in U. S. medical schools, but the place they occupy in the curriculum is unknown. Abroad, particularly in England, there have been considerable ferment and perhaps more activity in the development of the clinical concepts of preventive medicine than may be the case here, although the terminology is different. Abroad the terms of choice are medical ecology and social medicine.*

In England since 1943, three university departments of social medicine have come into being: in Oxford, Birmingham, and Edinburgh. The case for social medicine as a subject worthy of support in a university setting in Great Britain has a great exponent in Professor John A. Ryle, director of the Institute of Social Medicine at Oxford. In quoting Professor Ryle on this,[8] we should recall that his ideas on this subject are those of a clinician who believes that:

> The whole man and his family are still—or rather should be—the practicing physician's charge, but they can no longer be considered in detachment from their total environment or from the larger communities of which they are but a part. Communities, large and small, are now due for a more intimate study and care in respect of their health and sickness, but they, too, cannot be considered in detachment from their total environment and from the individuals and families of which they are composed.

And finally there is another function with which it would seem that university departments of preventive medicine should be concerned, namely, that besides gathering and integrating data, some attention should be paid to broad principles of action in the field of preventive medicine. If universities are not to be concerned with these principles it is hard to see what group will. I refer to the fact that decisions of policy are easier for "curative physicians" than for "preventive physicians." The "curative physican's" policies were laid down long ago, perhaps by Hippocrates. Medical schools have hardly meddled with them since. But the extent to which a physician should interfere with a patient's life in order to cure him is more easily defined than the extent to which a physician should interfere with an apparently well person in order to try to steer him away from future illness. Perhaps it could be settled by the patient or by the public and what he or it is willing to pay for. And yet, to my knowledge, if there are clinicians in the United States who have been concerned philosophically with the creation or molding of the basic principles in this

* The term "social medicine" as used in England turns out to be quite close in its context to the clinical approach to preventive medicine outlined above. Social medicine is not popular in the United States, perhaps because it brings up visions of "socialized medicine." To us it also smacks more of legal, economic, or political concepts of medicine than of clinical concepts. This article carries with it no plea for the introduction of the term social medicine in this country but merely that it be recognized in its true context. For further definitions, see reference 2.

field, they have not been very vocal.† Actually the principles or hypothetical creed of preventive medicine does not seem to have been mapped by any special group. Our civilization has been literally swept along, bolstered up somewhat by Christian ideals and legal decisions as to what appears to be right. Most people have at least assumed it to be axiomatic for doctors (and everyone else, for that matter) to prolong life at any cost and to prevent any preventable disease, the way one should prevent any trouble, if possible. But limitations of space preclude further discussion here. The question would require a whole chapter in itself, and would call for some thoughts on the biological aspects of disease, such as those that can be found in the works of Charles Nicolle[9] and Burnet.[10] The query here is whether physicians or biologists can rightfully assume that all human disease is necessarily bad and therefore that all disease should be prevented. Certainly the acquisition of mumps and German measles, before boys and girls reach puberty, is not bad at the present time. How bad different diseases are becomes a matter of mature judgment, perhaps of mature clinical judgment. Clinicians or pathologists who are interested in the natural history of disease should be in a better position than most to map the basic ideas for disease control, and an opportunity is lost if medical schools do not recognize this fact.

† In the United States there is no dearth of national organizations and their advisory committees which deal with preventive medicine and public health practices. These are identified with the American Public Health Association, The American Medical Association, and they also represent various governmental agencies, such as the U. S. Public Health Service, the Division of Medical Sciences of the National Research Council, etc. But so far as I know these organizations and their consulting committees are mainly concerned with administrative policy, technical aspects, standards, and expediency with regard to preventive medicine. One does not often hear of their meddling with basic questions, such as the desirability of reducing infant mortality or of lengthening the span of human life.

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Speak ye the pure delight whose favored steps
The lamp of science through the jealous maze
Of nature guides, when haply you reveal
Her secret honors.

—Mark Akenside
The Pleasures of Imagination II, 1744.

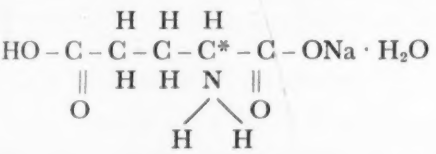
SCIENCE ON THE MARCH

MONOSODIUM GLUTAMATE—IMPROVER OF NATURAL FOOD FLAVORS

RADIO'S singing commercial relies on catchy phrases tied in with a melody to make the consumer conscious of the virtues of a manufacturer's product. "Accentuate the positive, eliminate the negative" might well become the theme song for monosodium glutamate, particularly now that it is being sold directly to the housewife as the third shaker for the dining table.

Because earlier preparations of monosodium glutamate of relatively low degree of purity exhibited a meatlike flavor, the general belief existed (and still exists in many quarters) that glutamate should be used as a seasoning for imparting meat flavors. Continued refinement in production methods has been responsible for progressive increases in purity, until the present commercial product (the monohydrate) is seldom less than 99 per cent pure. Only when the pure product became available was its unique property of accentuating natural food flavors and eliminating undesirable qualities fully appreciated.

The molecular structure of commercial monosodium glutamate monohydrate may be presented as follows:



The starred atom is asymmetric. The naturally occurring form of glutamic acid, that derived from protein hydrolysates or other natural sources, is the dextrorotatory form, l (+) glutamic; the "l" refers to its structural relationship to the other amino acids, most of which are levorotatory, the (+) to the direction of rotation. Frequently the naturally occurring form is indicated as d-glutamic acid, but l (+) glutamic acid is a more proper designation. The 1 per cent impurity in commercial monosodium glutamate monohydrate consists mainly of free moisture, salt, and traces of other amino acids.

The introduction of monosodium glutamate into foods for human consumption, its method of production, the mechanism by which it enhances food acceptability, and its physiological functions in the mammalian organism are all chapters in an interesting story. To hear this story firsthand from those who were largely responsible for introducing monosodium glutamate into the American diet and from those currently engaged in research investigations of this chemical compound, more than 120 food technologists from all parts of the country gathered in Chicago one day in March 1948 to participate in a symposium on the "Flavor and Acceptability of Monosodium Glutamate." This meeting was sponsored by The Quartermaster Food and Container Institute for the Armed Forces and the Industrial Associates of that Institute. The interest of the U. S. Armed Forces in increasing the acceptability of ration items is matched only by that of progressive food processors striving to gain competitive advantages for their own products. This meeting was effective in bringing to the attention of the American food industry as a whole the advantages of adding glutamate to food products, not for imparting a flavor of its own but for physiologically promoting and prolonging sensory acuity in the consumer for the desirable natural flavors in the products so supplemented.

History of Monosodium Glutamate

The German chemist Ritthausen was the first to isolate glutamic acid from an acid hydrolysate of gliadin, a component of wheat gluten; gliadin containing approximately 46 per cent of glutamic acid is the richest natural source of this material. Although synthetic glutamic acid is available (synthesis first accomplished by Wolff in 1890), the synthetic approach is far more costly than that based upon isolation of the amino acid from natural sources. Furthermore, the synthetic product is usually the racemic mixture, from which it is not commercially feasible to isolate the active, or dextrorotatory, form, and it is only the latter that exhibits flavor-accentuating value.

The contribution of glutamate to the building up of food flavors undoubtedly originated in the discovery in the Orient of a process for converting soybeans into soy sauce. Enzymic digestion occurs in this conversion process, with the result that free amino acids, including glutamic, are found. Soy protein contains approximately 20 per cent of glutamic acid. The protein in addition is rich in amide nitrogen, also susceptible to enzymic hydrolysis, with the result that Oriental soy sauces contain, as

shown in recent years, ammonium salts of the amino acids, including ammonium glutamate.

In 1912 a Japanese chemist, Ikeda, reported before the Eighth International Congress of Applied Chemistry meeting in New York City that glutamic acid recovered from the hydrolysate of a dried seaweed, *Laminaria japonica,* and partially neutralized with sodium hydroxide, exhibited a desirable meatlike taste. Patentable claims had been granted a number of years prior to the report (British Patent No. 9440). Suzuki and Company, of Tokyo, became interested in Ikeda's process and soon began producing monosodium glutamate on a commercial scale, the product being sold under the trade-mark *Aji-no-Moto,* meaning "the essence of taste." The basic Suzuki-Ikeda patents expired in 1929, and by 1936 there were some seventy small firms manufacturing glutamate in Japan, basing the process for the most part on hydrolysis of wheat gluten. Suzuki and Company, however, remained the major producers, accounting for more than half the total Japanese output. The yearly production was sizable, the annual output of all Japanese manufacturers in 1933 being 9,000,000 pounds.

The growth of the glutamate industry in Japan during the first twenty years of its history has exceeded that in the United States—an observation calling for some comment. Oriental diets are greatly restricted as compared to those generally available to the over-all population in this country. The monotony of taste of Oriental dishes undoubtedly prompted the development of soy sauce and ultimately led to glutamate supplementation of soups, of rice and fish meals, and of soy sauce itself.

Suzuki and Company tried with but little success to introduce monosodium glutamate into the United States. The first successful American manufacturer of glutamate in this country was the Huron Milling Company, of Harbor Beach, Michigan. As manufacturers of various starches, including wheat, this company had a wheat gluten by-product, a logical base for glutamate production. In August 1934 commercial manufacture of the product was initiated by the Huron Milling Company under the direction of Patten, who had spent a number of years in Germany working with Kossel on problems of amino-acid technology.

All methods of glutamate production up to this time depended upon acid hydrolysis of a protein-bearing material, particularly wheat gluten. Concurrent with the attempts of the Huron Milling Company to devise a commercial method for the preparation of glutamate in this country, a beet-sugar entrepreneur by the name of Larrowe conducted large-scale plant experiments at Rossford, Ohio, with the object of isolating glutamic acid from Steffen's waste, the mother liquor remaining after the crystallization and removal of sugar (sucrose) from the beet juices. The acid-hydrolytic methods employed by the Japanese Suzuki and Company proved to be commercially not feasible for the isolation of glutamic acid from Steffen's waste. Marshall, now president of the Rumford Chemical Works, was retained by Larrowe as a consultant for setting up an efficient manufacturing method. Marshall found that, contrary to general belief, racemization of glutamic acid to the optically inactive mixture need not occur during alkaline digestion of the Steffen's waste. By a judicious choice of alkali concentration, temperature, and reaction time, it was possible to obtain l (+) glutamic acid in satisfactory yield. The successful commercial production of monosodium glutamate from Steffen's waste led to the founding of the Amino Products Company, which subsequently became a subsidiary of International Minerals and Chemical Corporation. Today the Huron Milling Company, operating out of Harbor Beach, and the Amino Products Company, with plants in Rossford, Ohio, and San Jose, California, are responsible for more than 80 per cent of the total glutamate production in this country. The latter figure approximates 7,000,000 pounds yearly, with no indication that a plateau in consumption is in sight. During recent years, the Staley Manufacturing Company at Decatur, Illinois, and General Mills, Inc., at Keokuk, Iowa, have entered the field of glutamate manufacture.

Methods of Manufacture

Glutamic acid is one of the most common of the amino acids, being a constituent of practically all proteins. Wheat gluten is one of the richest and probably the most economical source of this amino acid, the proteins in wheat gluten containing approximately 40 per cent glutamic acid. In Steffen's waste the substance is present as pyrrolidone carboxylic acid (the internal anhydride of glutamic acid) in variable concentrations up to 15 per cent of the total solids.

Any one of three hydrolytic methods can conceivably be used in the first phase of monosodium glutamate manufacture; these involve the use of proteolytic enzymes, acids or alkalis. Enzymic digestion is not favored in this country because of the long holding periods required to effect a substantial (never complete) hydrolysis of the protein, the possibility of microbiological contamination of the digestion mixture, and the inability to obtain as the end item monosodium glutamate of the high

purity required (in the neighborhood of 99 per cent). Hydrolysis with acid is free from the criticisms mentioned. The only objection to the use of acid is its corrosive action on equipment. Hydrolysis with alkali is better tolerated by processing equipment; however, the products found in alkaline digests of protein are optically inactive and hence contain only about 50 per cent of the desired l (+) isomer. Nevertheless, alkaline hydrolysis according to a specific procedure is currently used in the commercial manufacture of the monosodium glutamate from beet-sugar solution, practically without any racemization occurring. Acid hydrolysis is the preferred method when the substrate is protein, such as that found in wheat or corn gluten.

In preparing monosodium glutamate from wheat gluten, the protein is completely hydrolyzed by boiling or autoclaving with strong hydrochloric acid. After the humin is eliminated by filtration, much of the excess hydrochloric acid is removed by evaporation under reduced pressure. From the strongly acid hydrolysate the glutamic acid hydrochloride precipitates. The crystalline hydrochloride is dissolved in a minimal volume of water, treated with charcoal to remove color, filtered, and the solution adjusted to pH 3.3, the isoelectric point of glutamic acid. From this solution glutamic acid crystallizes. The glutamic acid is suspended in a minimal quantity of water and brought into solution with sodium hydroxide additions until pH 7 is attained. Upon concentration and chilling of the solution, the monosodium salt crystallizes. The dried product containing one molecule of water of hydration is the article of commerce. An approximately 67 per cent yield of the glutamic acid, known to be present in the wheat gluten, is recovered by this process. Considering the complexity of the process, particularly on a plant scale resulting in a daily production of about 10,000 pounds of monosodium glutamate, the yield of product is remarkably good.

The manufacture of monosodium glutamate from Steffen's waste follows a different procedure. Some sugar-beet juices contain sufficient quantities of glutamine to make practical the isolation of glutamic acid from this source. Other lots may contain little or no glutamine. The reasons for the differences are obscure; however, beets from certain geographical localities are uniformly high, and from others low, in glutamine content.

During the Steffen's process of liming (treatment with calcium oxide) beet molasses for the recovery of beet sugar, the glutamine present is largely converted to pyrrolidone carboxylic acid. The filtrate is treated with carbon dioxide to remove calcium ions and the clarified filtrate concentrated twenty-five fold to 60 or 70 per cent total solids content. In this form the material keeps indefinitely and may be shipped to distant plants for subsequent processing. The concentrated Steffen's waste is hydrolyzed with a strong sodium hydroxide solution. The hydrolyzed material is acidified with hydrochloric acid and concentrated *in vacuo*. After the centrifugal separation of precipitated inorganic salts, glutamic acid is recovered from the solution by adjusting the pH to 3.3 and holding at low temperatures. Sufficient glutamic acid is dissolved in a sodium hydroxide solution to bring the pH to 7, and the resulting solution is decolorized with charcoal. Following concentration and chilling of the solution, the monosodium glutamate crystallizes. The final product is dried in a rotary air drier and screened. Plant production by this process exceeds 9,000 pounds of monosodium glutamate per day, and the yield is variable, being a function of the initial glutamine concentration.

The price of monosodium glutamate to food processors is about $1.50 per pound. Its use as a food adjunct in such low concentrations as 0.05–0.5 per cent, however, negates its apparent high cost. Only because a constant market exists for by-products obtained in the manufacture of monosodium glutamate is it possible for the price to remain at its present level. The major by-product is the concentrated and subsequently neutralized filtrate (as a liquid, paste, or powder) obtained following the removal of the bulk of the glutamic acid hydrochloride from the wheat gluten hydrolysate. These concentrates of amino acid, containing in addition sugar-amino acid reaction products, have pronounced meaty flavors akin to those of the broth from well-browned beef, and when added to foods in sufficient amounts impart a dominant flavor to the final product. Frequently both a vegetable protein hydrolysate and monosodium glutamate are added to foods.

In all methods for the manufacture of monosodium glutamate, corrosion problems are of great magnitude. In solving the problems encountered, the glutamate industry in this country has contributed much to the nation's fabricating techniques for building equipment out of materials resistant to hydrochloric acid.

"Accentuating the Positive and Eliminating the Negative"

In a report on the *The Flavor of Meat and Meat Products* by the U. S. Department of Agriculture, Howe and Barbella stated as early as 1937 that purified monosodium glutamate is devoid of a

meatlike flavor. This report was largely neglected until Crocker, of the Arthur D. Little Laboratories, demonstrated how monosodium glutamate enhances food flavors.

Crocker investigated by direct study the generally held belief that monosodium glutamate imparts a meaty or chickenlike flavor to the foods supplemented. Meat products, including beef, pork, lamb, and chicken, were divided into juice and fiber fractions, and each examined separately by an objective taste panel for flavor in the cold raw state and after heating. It was found that the characteristic meaty flavor developed on heating is derived from the meat fiber rather than from the juice. The flavor of the meat fibers is not detectable when the nose is pinched, indicating that the favorable organoleptic properties of the cooked meat are due almost entirely to aroma. The volatile constituents are a mixture of hydrogen sulfide, various acids, and amines, presumably degradation products of the amino acids in the protein.

Solutions of monosodium glutamate, on the other hand, are entirely devoid of odor when pure. All four taste components (sweetness, sourness, saltiness, and bitterness) are detectable in flavoring such solutions. It is possible to match the taste of two thresholds of concentration of glutamate with a solution having 0.6 threshold of sweetness (sucrose), 0.7 of saltiness (sodium chloride), 0.3 of sourness (tartaric acid), and 0.9 of bitterness (caffeine). However, the synthetic flavor fails to match glutamate in enhancing natural food flavors. Monosodium glutamate not only increases salivary secretion for some time but also stimulates a tingling feeling in the mouth, and the taste sensation persists. This persistence effect occurs in the whole of the mouth region, including the roof of the mouth and the throat. This glutamate sensation, independent of true taste, has been described as a "feeling of satisfaction" and adds psychologically to the flavor of food eaten. Crocker postulates that this is due to the glutamate acting as a functional amine and in this capacity reaching and stimulating nerve endings in the buccal cavity. The fact that isomers and homologues are inactive points to the need for a specific molecular structure to obtain the glutamate effect, and supports Crocker's hypothesis.

The other amino acids, as such, or as their neutral salts, are also without odor. At pH 7 they are all sweet but usually somewhat bitter. Saltiness and sourness, associated with glutamic acid and its sodium salt, are not detectable in flavoring solutions of the other amino acids, nor do these other solutions leave a persistent tingling feeling in the mouth.

Crocker concludes that since the flavor of cooked meat is predominantly odor and pure monosodium glutamate is odorless, meat flavor cannot be due to, or be simulated by, glutamate. The pure glutamate commercially available in this country, nevertheless, has greater value in foods than the old odoriferous glutamates, because of the ability of the former to reinforce or accentuate natural food flavors without introducing a flavor of its own.

Studies conducted concurrently by Galvin, of the Huron Milling Company, on pure solutions of amino acids yielded results similar to these reported by Crocker. Galvin, however, emphasizes the importance of salt in augmenting the glutamate effect. The glutamate taste is also affected by pH, optimal results being achieved between pH 6 and 8. Taste diminishes slightly at pH 5 to approximately 80 per cent of original intensity, and progressively greater reductions are apparent with decreasing pH of the solution. Bearing in mind that monosodium glutamate accentuates sweetness also, Galvin points out that, for the most economical use of this material, adjustments should be made in saltiness, in pH, and in sweetness by the addition of conventional and low-cost flavoring agents. In this way full advantage is taken of the glutamate effect in promoting and prolonging sensory acuity in the consumer for desirable natural flavors.

In attempting to make objective measurements on flavors of foods, the investigator is handicapped by the usual limitations of subjective impressions, prejudices, and preferences. Nevertheless, it is possible by open-panel discussion to determine the principal notes or points of odor and flavor on unseasoned foods. A composite of these points has been called the flavor profile. Subsequent observations may then be made on the effect of various supplements upon the specific aspects of the flavor profile, without reliance upon preference. Such studies by Cairncross and Sjostrom, also of Arthur D. Little, Inc., have shown that monosodium glutamate, even in subthreshold concentrations, accentuates sweet and salty tastes in food when these are present in less than optimal amounts. Sourness and bitterness appear to be suppressed. These effects are noted with concentrations of glutamate that in themselves are not detectable. The improvement in flavor appeal is most readily detected in meats, sea foods, stews, soups, chowders, vegetables, and in dehydrated foods on reconstitution. Foods supplemented with glutamate and held on steam tables for extended periods do not suffer in flavor acceptability to the same degree as the foods without the supplement. The flavor-accentuating property of glutamate is retained indefinitely regardless

of the holding conditions to which the food may be exposed. Undesirable flavors in certain foods are suppressed by glutamate; these include the sharpness in onion flavor, rawness in many vegetables and some meats, the flavor of peel and earthiness in vegetables, such as in potatoes, and a fishy note sometimes present in Lima beans. Monosodium glutamate should be added to foods prior to complete seasoning; otherwise it might upset the balance attained with these other agents alone.

Recent studies by Hac, Long, and Blish, of International Minerals and Chemical Corporation, have shown that free glutamic acid occurs naturally in a large variety of vegetables, and in fish and meat products, in the range of 0.005–0.23 per cent. Because young or freshly harvested vegetables have a higher free glutamic acid content, and because the free glutamic acid decreases as the vegetables approach maturity or as a result of short storage in the refrigerator, a plausible explanation for the greater flavor acceptance of such products is at hand. A high free glutamic acid content (0.13–0.23 per cent) may be one of the reasons, too, why mushrooms augment the flavors of the many dishes to which they are added.

For a time the use of monosodium glutamate by food processors was complicated by the ruling of the Food and Drug Administration that a product supplemented with glutamate must bear the label "Artificially flavored with monosodium glutamate." The recent decision of the Administration that the "artificial-flavoring" designation need no longer be included in the label declaration was in part prompted by the demonstration that free glutamic acid occurs naturally in prepared foods and largely by the demonstration that it was used widely in processed foods to enhance natural flavors and not to impart a flavor of its own. Nevertheless, the presence of *added* glutamate must still be declared.

Not all foods are improved in flavor by glutamate supplementation, however; in this category are sweet products and fatty foods. In fact, supplemented carbonated sweet drinks suffer in flavor appeal, since the desirable evanescent taste (one that disappears quickly) of such products is converted to a lingering, persistent flavor; the flavor is reminiscent of the unsupplemented product after the carbonation has been dissipated.

Anson, at Continental Foods, Inc.—a company that makes a noodle soup mix dependent for its flavor in part on a balance of flavoring agents, including monosodium glutamate and a wheat gluten hydrolysate—has directed attention to an important problem associated with glutamate fortification of dry mixes. This is concerned with the changes in flavor that may develop during extended storage of the supplemented food. Various carbohydrate substances, particularly the reducing sugars, yield brown substances when heated at a neutral pH. This decomposition and polymerization of sugars is catalyzed by compounds having free amino groups and is frequently referred to as the Maillard, or browning, reaction. Since monosodium glutamate contains a free amino group and is used in products of neutral pH, this material has been involved in the browning observed during storage of certain supplemented foods. This undesirable property is not peculiar to glutamate, since the other amino acids behave similarly. Thus, protein hydrolysates, also used for flavoring purposes, participate in this reaction. The end products of the reaction not only are objectionable in the brown color but also in the bitter and caramel-like flavor imparted to the food. In all fairness it should be pointed out that all concentrated food products containing reducing carbohydrates (even in very small concentrations) and protein as the sole source of free amino groups are susceptible to this form of deterioration. In an amino-acid supplemented food, however, the number of free amino groups per unit of weight is obviously high, and hence the browning reaction is more likely to proceed in such foods to a greater extent. Normally the rate of browning is at a maximum in foods containing 10–15 per cent moisture. Thus the browning reaction is a serious problem in dry and dehydrated foods containing the essential reactants, and not in dilute products, such as soups. Reducing the moisture content of the foods to 0.5–5 per cent, storage of the products at low temperatures, sulfite treatment, and adjustment of the pH to an acid reaction have proved effective in inhibiting browning of dehydrated foods. In the latter method a solid alkalizing agent in a potentially active form, but physically isolated in the dry product from the other materials present, is added so that the pH of the reconstituted product is in the proper range of acceptability.

Physiological Functions of Glumatic Acid

Glutamic acid is a so-called nonessential amino acid; the organism is not dependent upon a dietary source of this amino acid for protein synthesis. And yet glutamic acid exhibits a number of interesting functions. It has a rather marked specific dynamic action, being exceeded in this regard only by phenylalanine and tyrosine. It is one of the amino acids which can be converted in vivo to glucose or glycogen, and it is one of the few amino acids that has lipotropic activity. It is also involved in reversi-

ble transaminase reactions in the body, converting keto acids to amino acids, it in turn being converted to alpha ketoglutaric acid. It is an important constituent of many biologically active compounds such as glutathione, folic acid (peteroyl glutamic acid—a vitamin), and insulin. It is unique among the amino acids in that it alone is utilized by cerebral tissue; it is converted to the acid amide, glutamine, in which form it may be used by brain tissue as a source of energy. In clinical trials with moderate doses given to mentally retarded children, it has been reported to increase the IQ and produce other beneficial effects, provided there is no cessation of dosage.

With recent discoveries of the important physiological roles played by the so-called nonessential amino acids, it has been facetiously remarked that the nonessential amino acids are so essential that the body cannot rely on outside sources but must synthesize them itself. This interpretation would seem to apply to glutamic acid in view of the recognized functions of this amino acid.

With monosodium glutamate in hand, the chemist need not hesitate to descend from his ivory tower and enter the sanctum sanctorum of the home (sometimes referred to as the kitchen) and demonstrate to his hitherto skeptical wife tangible evidence of real scientific accomplishment.

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THE NEW YORK MEETING, DECEMBER 26–31, 1949

THE 116th Meeting of the American Association for the Advancement of Science—the Sixth New York Meeting—was by far the largest in the Association's 101-year history. It also was one of the most successful. An exceptional attendance that exceeded the estimates of the secretaries of the sections and participating societies, in this instance, reflected the generally high quality of the programs.

All but one of the Association's 17 sections and subsections and 61 other organizations, principally affiliated and associated societies, held a total of 398 sessions, business meetings, and meal functions in the five Penn Zone hotels, the Manhattan Center, and academic halls on the campus of Columbia University. Projection was required for 294 sessions.

Table 1 indicates that there were registrants from every state in the union except Arizona and Idaho. In the hotels—Statler, New Yorker, McAlpin, Governor Clinton, and Martinique—42 public rooms, and at Columbia University, 21 meeting rooms, were used throughout the week. Except for the American Sociological Society, which came in late and engaged facilities at the Manhattan Center, no society was called upon to pay anything for either meeting rooms or projection.

The registration at the New York Meeting was 7,014. In comparison, the largest previous Meeting was Chicago (1947), which had a registration of 4,940. Registration at the Fifth New York Meeting of 1928 was 3,935. On only four other occasions has AAAS registration exceeded 3,000; namely, Washington, D. C., 1924 (4,206); Philadelphia, 1940 (3,339); Philadelphia, 1926 (3,181); and Indianapolis, 1937 (3,094).

TABLE 1

DISTRIBUTION OF REGISTRANTS AT AAAS NEW YORK MEETING (1949) BY STATES

New York	2,585
New Jersey	598
Pennsylvania	514
Massachusetts	351
Maryland	265
Illinois	253
Connecticut	248
District of Columbia	238
Ohio	216
Michigan	207
Indiana	113
Virginia	102
North Carolina	100
California	96
Wisconsin	93
Tennessee	67
Missouri	59
Iowa	57
Georgia	53
Texas	52
Louisiana	50
Minnesota	50
Rhode Island	44
Maine	43
West Virginia	43
Vermont	33
New Hampshire	29
Delaware	28
Kansas	24
Colorado	23
Florida	23
Kentucky	23
Washington	21
Alabama	20
South Carolina	19
Oklahoma	18
Nebraska	17
Mississippi	16
New Mexico	9
Arkansas	8

Utah	8
Montana	5
Wyoming	5
Oregon	4
North Dakota	3
South Dakota	2
Nevada	1

In Table 2, the scientific fields of the 7,014 registrants are grouped under the Association's sections A–X.

TABLE 2

TABULATION OF THE SCIENTIFIC FIELDS OF INTEREST TO REGISTRANTS AT THE AAAS NEW YORK MEETING (1949)

A—*Mathematics*	
Mathematics	103
Mathematical Statistics	20
B—*Physics*	
Biophysics	25
Electronics	9
Meteorology	5
Nucleonics	5
Physics (incl. Optics, Sound, *et al.*)	299
C—*Chemistry*	
Biochemistry	196
Chemistry (incl. Inorganic, Organic)	442
D—*Astronomy*	
Astronomy	49
E—*Geology and Geography*	
Geography	19
Geology	116
F—*Zoological Sciences*	
Embryology	75
Entomology	38
Histology	11
Ichthyology	5
Parasitology	172
Protozoology	24
Zoology (incl. Anatomy, Animal Behavior, *et al.*)	568
G—*Biological Sciences*	
Bacteriology	93
Biology	461
Biometry	7
Cytogenetics	15
Cytology (incl. Cellular Physiology)	88
Ecology	91
Evolution	7
Fisheries Biology	17
Genetics (incl. Human Genetics)	265
Limnology	21
Microbiology	80
Oceanography	15
Paleontology	10
Radiobiology	10
H—*Botanical Sciences*	
Botany (incl. Bryology, Phycology)	452
Mycology	85
Paleobotany	12
Plant Morphology	14
Plant Pathology	166
Plant Physiology	150
Plant Taxonomy	28
H—*Anthropology*	
Anthropology	51
I—*Psychology*	
Child Development	23
Psychology	236
K—*Social and Economic Sciences*	
Economics	23
Rural Sociology	29
Sociology	435
L—*History and Philosophy of Science*	
History and Philosophy of Science	24
M—*Engineering*	
Engineering (all types)	88
N—*Medical Sciences*	
Cancer Research	10
Dentistry	41
Endocrinology	97
Medicine (incl. Pathology, Surgery, *et al.*)	383
Neurology	6
Nutrition and Food Technology	24
Pharmacology	66
Physiology	208
Psychiatry	22
O—*Agricultural Sciences*	
Agriculture (incl. Soils, Agronomy)	27
Forestry	5
Horticulture	8
Q—*Education*	
Educational Books and Publishing	26
Education	55
Science Teaching	114
X—*Science in General*	
Nature Study and Conservation	27
No field stated and general	646

The Annual Science Exposition, housed in the Penn Top and Salle Moderne on the eighteenth floor of the Hotel Statler, also broke precedents. Between midnight of Sunday, Christmas Day, and 4: 00 A. M., 86 booths were erected, and by opening time, 2: 00 P. M., December 26, the displays of 70 exhibitors were all in place. The Annual Science Exposition of 1949 was not only the largest but one of the most attractive and diversified in the annals of the Association. It is increasingly clear that the Exposition, which had its beginnings in 1924, is of mutual advantage both to the scientists who attend and to those who provide the tools and materials of science. In the Arena of Cleveland's Public Auditorium in 1950 no exhibitor need be turned away for lack of sufficient space.

In closing this report of certain phases of the 116th Meeting, the writer acknowledges his great indebtedness to the large number who cooperated in various ways to make the Meeting a success. Without such full cooperation, it would have been quite otherwise.

RAYMOND L. TAYLOR
Assistant Administrative Secretary, AAAS

BOOK REVIEWS

UNDERSTANDING SCIENCE

Man and His Physical Universe. (Rev. ed.) Frank Covert Jean, Ezra Clarence Harrah, and Fred Louis Herman. vii + 643 pp. Illus. $4.00. Ginn. Boston.

THIS book was originally published in 1934. A first revision was published in 1943, and now, six years later, a second revision has been necessary to bring the book up to date. It is intended as a text in general science survey courses for students who do not expect to become scientific specialists, but who desire a broad view of science for its cultural value. The book covers astronomy, physics, chemistry, and geology. So broad a scope naturally requires joint authorship by a number of specialists.

Such a science survey text differs in one important respect from a specialized textbook. The latter is essentially unemotional, whereas the former does not hesitate to recognize the student's natural instincts of wonder and admiration. For this reason such a book is interesting to those who, confronted by recent scientific developments, may feel the lack of scientific study in their college days. This book does not pass over aspects of the subject which may influence the student's philosophy of life.

In discussing astronomy the book gives an excellent perspective of the historical development of this branch of science, pointing out that except for a few flashes of genius man did not discover a great deal about the cosmos in which he dwells until the seventeenth century; and that the subsequent tremendous expansion in man's conception of space has greatly affected his thinking. Nevertheless, some of the ancient superstitions have not yet completely disappeared—for instance, belief in astrology and horoscopes.

The book describes the most recent astronomical instruments, such as the new 200-inch telescope at Mount Palomar. It also describes smaller instruments, such as the thermocouple used for measuring the radiant energy from a star. Here there is a misstatement to which attention should be called. The book says: "Since one of the two pieces of metal heats faster than the other, when the point of union of the two metals is heated a feeble current of electricity is produced." Were this so, the current would stop when the hot junction reached its maximum temperature. Bismuth and lead have nearly the same specific heat, but form a more powerful thermoelectric couple than some other metals whose specific heats differ more widely.

A discussion is given of the different hypotheses that have been advanced to explain the formation of the solar system, and also of the question: Are there other worlds than ours?

Physics and chemistry are given the same perspective treatment as astronomy. The unification of the co cepts of matter and energy in recent years is given a extensive explanation that is up to date and accurat In discussing the Bohr atom the authors state that a though this has been a distinct step forward in atom science it, like other earlier theories, has been found have certain imperfections, and is likely to be modifi or replaced in the future. This is a point passed over silence by certain other writers. Perhaps the great su cess of the atomic bomb has blinded the world to th three fundamental defects in the Bohr theory.

On page 162 there is a typographical error that ma cause trouble to a student. The standard abbreviatio for "million electron volts" is "Mev." The book giv "mev," which, strictly speaking, should mean "tho sandths of an electron volt." On page 207 there is an other error. In discussing Davy's isolation of potassiu it is said that Davy dissolved caustic potash in a plat num spoon and sent an electric current through the solu tion. It is true that Davy first attempted to isolate pota sium in this way, but found it necessary to change hi plan of attack. In his own words: "The presence o water appearing thus to prevent any decomposition used potash in igneous fusion."

The book closes with a section describing the struc ture of the earth and its surrounding atmosphere. Th chief factors of weather are mentioned, and the use o pilot and sounding balloons is described. In geolog there is a description of the various methods that hav been used in estimating the age of the earth. It pointed out that geological changes are still in progres

Each section of the book contains a list of question for study, and copious references.

PAUL R. HEY

Washington, D. C.

The World of Life. Wolfgang F. Pauli. x + 653 pp. Illu $5.00. Houghton Mifflin. Boston.

PAULI has written this large general biology tex *The World of Life,* for the nontechnical studen with three stated objectives: It is intended to give th genesis of facts and ideas, not merely to declare them it seeks to attract and stimulate the student, not to dos him with information; and it attempts to organize th main patterns of living organisms around the motif o evolution, without de-emphasizing any others. To thes admirable ends are devoted 600 pages of double-colum text, a classification of plants and animals, a glossar of nearly 700 biological terms, and more than 50 figures. The latter—line drawings, photographs, charts etc.—are excellent, both in form and content. The tex is more exceptionable.

As to interest and attractiveness for students, th judgment of students is the ultimate test. The autho

ports success from this viewpoint even with the less ished materials that have become this book. Certainly sincere effort has been made to enrich facts with sig- ficance, to tie them to normal human interests. That ey have also been shown in their genesis, that the ader is led from phenomenon to interpretation to neralization, is less obvious. The categorical assertion mains the overwhelming rule. Granting that observa- nal and experimental findings must be so stated, it seems that there is an excessive number of them d a paucity of intellectual maneuvering with them.

This is particularly the case for the more functional d dynamic material. The book thus emerges as de- iptive more than analytic; and while this mode es indeed give a good picture of organisms as ob- cts—of their kinds, history, development, interaction, d so of "the web of life" and "man on the planet"— is weak and didactic in its presentation of organisms machines. Structure and history thus dominate over nction and mechanism, despite the author's hope and e editor's assurance that such "slanting" has been oided. In terms of what the volume does offer, it is attractive text and certainly a bargain at its list price five dollars.

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he University of Chicago

OF HUMAN BONDAGE—II

eath of a Science in Russia. Conway Zirkle, Ed. xiv + 319 pp. $3.75. University of Pennsylvania Press. Philadelphia.

NO ONE who has tried to expose the Communists has ever succeeded in showing up the intellectual honesty of Party Line thinking as have the Russians emselves." So declares Conway Zirkle, and his book, hich has to do with the fate of genetics in the Soviet main, goes a long way in proving the statement. It is e latest addition to a large collection of writings hav- g to do with Lysenkoism. Although based on the same *tuation in Biological Science,* reviewed in this journal t December, it is a critical treatment of the whole bacle.

After setting the stage with some necessary props that e reader must recognize about the science of in- ritance, and fortifying the scene with some thought- l and illuminating excerpts from recent writings of ch internationally known geneticists as Darlington, obzhansky, and Muller, the editor, for the most part, s the Russians carry the tragedy to its completion. ith their speeches just as recorded in *Pravda,* these aracters tell of the grim victory of dialectical mate- lism over science; of charlatans and ignorant im- sters over their own honest countrymen; of an ounding twentieth-century quackery ousting from a ilized country a science in which it had made great ides and which it desperately needed for its own agri- ltural development.

Little Marxist orthodoxy was demanded of Soviet scientists for nearly two decades following the revolution. Aided by generous appropriations for staffs and laboratories, they made great progress. The genius of Soviet politics, Lenin himself, appointed Dr. N. I. Vavilov (a non-Communist) to head the Lenin Academy of Agricultural Sciences. The work of this great investigator was acclaimed by geneticists all over the world. But by 1936 some political infiltration was indicated. By 1939, when Vavilov was prevented from presiding over the International Congress of Genetics at Edinburgh and neither he nor any other Russian showed up, it was plain to the outside world that serious trouble was brewing. It was about this time that one Trofim Denisovich Lysenko, an obscure agronomist more versed in politics than in science, arose like a genie out of a Ukrainian wheatfield. When this "man of destiny" replaced Vavilov as head of the Lenin Academy of Agricultural Sciences, and Vavilov was sent to Siberia (and to his death, as was discovered later), it was evident that something dire and ugly was happening in Russian science. In addition to Vavilov, many other well-known Soviet geneticists were dropping out of sight. All this merely led up to the final denouement which was staged at Moscow in August 1948. In gangster terms, this was the "pay-off." Unmindful geneticists were told to recant their "bourgeois-idealistic science," accept Lysenko and his resurrected Michurinist teaching of the inheritance of acquired characters, or else. Lysenko's science had the approval of the Central Committee.

The editor searches for causes behind these incredible happenings. He is not sure, but ventures the possibility that authoritarianism simply cannot allow the existence of the intellectual standards of free scientific inquiry. In putting together this display of Soviet self-sabotage, Professor Zirkle has done an excellent service to the West's understanding of Russia today. What we have most difficulty in understanding, however, is the ingenuousness of the Central Committee in allowing us to gain such insight.

A. L. STRAND

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CITIZEN OF NEW YORK

Peter Cooper. Edward C. Mack. xvi + 432 pp. Illus. $5.00. Duell, Sloan & Pearce. New York.

WHAT is the American way of life? What do we mean when we speak of the privileges inherent in our democracy? These are questions often in the news of late; we have found it difficult to give, in words, the answers each man so proudly feels. The life of Peter Cooper, "Citizen of New York," is the symbol we have sought. The author, in this painstaking, scholarly, documented study of the philanthropist, has the exact words to express it. "Given a little capital, a little shrewdness, and a great capacity for work, the future was virtually unlimited." He adds other words, such as ingenuity, innate mechanical genius, friendliness, vision, faith, and optimistic idealism, to round out the picture.

The biography begins with a brief account of Peter

Cooper's ancestry and then shows immediately that "the boy was father of the man." His life, 1791–1883, spanned the growth of the United States from the Constitution to the days of the great industrialists. In each of Cooper's many years he was inquisitive, adventurous, and experimental. His first invention was a machine to lighten his mother's laundry labor. His life, dedicated to "relieve suffering and help humanize the world" was crowned by the great Cooper Union in New York, founded as "the gateway to a richer and better life for the community."

But long before the iron beams were rolled for that building in his own foundry, Peter Cooper founded his fortune. He had little schooling but was "a competent if not master craftsman in a dozen fields." Everything interested him. First he learned the manufacture of hats; when "his father turned to brick-making he was made useful" there. He helped in a brewery and he carted foundation stones; he manufactured "shearing machines" and was, for a time, a grocer. He never "made a failure." It was however, as a manufacturer of glue that he acquired great wealth.

Meanwhile he was intensely interested in steam engines and torpedo boats and flying machines, real estate and fire fighting and New York's water supply. He helped change the patent laws and improved the New York public school system. He worked on ocean telegraphy and railroads and the Panama Canal and New York politics. "All his life he exhibited a strange duality: shrewd and careful (even acquisitive) in his business, he was as trusting and optimistic (and naïve) as a baby when dealing with politicians, inventors or beggars." He looked on "work as a duty and justified success as the reward for labor." Even at ninety, he was alert to new ideas to better man's living conditions.

Some of the evaluation of Peter Cooper must be guesswork; he left little record of his thoughts and feelings. Of his activities there are far too few documents, only one biography, one dictated *Reminiscences,* and many legends. Using every possible source, Mr. Mack has drawn a glowing portrait of a self-made man, the "Benjamin Franklin of the nineteenth century," an American idol of all time.

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THE WAR AGAINST DISEASE

Cancer. Beka Doherty. xiv + 327 pp. $3.00. Random House. New York.

"As long as people continue to contribute to anti-cancer campaigns, either through taxes or private donations, they have a right to know what is being done with their funds." Beka Doherty fulfills this premise most adequately. She has written a thoughtful, balanced review of the present status of the cancer problem, developing the material under four main components: cancer and the patient, cancer and the physician, cancer as a research problem, and cancer as a public health problem. The timeliness of the book is enhanced by the appendices, listing approved cancer clinics, hospitals, detection centers, and foundations in the United State

The story of research, diagnosis, and treatment o cancer is clearly and factually told. Points of empha may be questioned, and the style may not meet wi universal approval from scientists, but these minor d ficiencies—or, rather, differences of opinion—do n detract from the real value of the presentation. T author's wide experience in journalism has led h occasionally into "journalese," such as the use of som what inappropriate analogies and dramatic "huma interest" episodes. These detract from rather than i prove the report, in the opinion of this reviewer. Neith does there appear to be any particular point in su statements as ". . . steroid hormones; this curious ter which sounds as if it belongs in a dry-cleaning esta lishment . . . ," or " 'mitochondria' (little grai splotches)."

Many active workers in the field of cancer cooperate in the preparation of the volume. Perhaps because this, there is apparent reluctance to mention ind vidual investigators. In fact, only one living worke Peyton Rous, is mentioned by name in connection wi his scientific contributions. Specific reference to Litt Kennaway, Lacassagne, Loeb, Huggins, and Bittner, mention a few, would have added to completeness a interest. It is also inadequately stressed that the w against cancer is an international one. Proper credit missing for the achievements of our British, Frenc Scandinavian, and Russian colleagues. In the w against cancer, there are many fronts!

Cancer can be recommended highly to all intellige laymen and students who are interested in the pres status of the cancer problem in the United States. can also serve as a good model for the developing a of describing to lay audiences the complex advances science, especially in rapidly shifting and changing are such as cancer, where any story written at the mom can at best be only a progress report.

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ONE EQUALS ONE

The Science of Culture. A Study of Man and Civiliz tion. Leslie A. White. xx + 444 pp. $6.00. Farra Straus. New York.

THIS collection of essays presents a strong case f culturology by the most articulate exponent of th "new science." White contends that the proper domai of culturology is that special order of phenomena know as the cultural or superorganic. These phenomena a wholly distinct from the biological and psychologic phenomena. They are of a higher level and require the

n concepts and methods. They must be "explained" clusively in terms of themselves. The argument for is is that because there are no inherent biological or ychological differences between groups of mankind hich account for differences in their behavior, mind d body being constants, the cultural variable is caused differences in the cultural tradition. Culture has its n laws, which determine the course of its evolution. is a pure illusion to suppose that man has free will or y power to control his destiny. Great men are enely creatures of their cultures, which they cannot in e least affect.

No social scientist will quarrel with the concept of lture. White's uncompromising insistence that "exanations" of culture be kept on a strictly culturolog-al level, however, leads him into specious reasoning. the objective is to account for *cultural differences,* it a tautology to say that "variations of human behavior e functions of a cultural variable" (p. 139). A varible has to be a function of something other than itself. ultural differences are in part a function of the enronmental variable, which White will not admit into e formula of causality. He disposes of environment in ne short paragraph (p. 339), which declares it to be constant, and in a brief footnote (p. 368), which dmits its local importance but states that culturological laws" are concerned with world culture as a whole, l environments being averaged to form a constant ctor! In using this extraordinary logic, White forgets hat he has insisted that it is *local differences* and not lture change in general which need to be "explained." vidently shunning the stigma of "environmental deterinism," he refuses to see that any given cultural heriage would have to be adapted to local habitats and that he processes of adaptation, the cultural ecology, would e creative ones.

Mind and body might be reckoned as constants if ne were interested in explaining only cultural differnces. White, however, seeks culturological "laws" of hy and how *any* culture develops rather than explanaions of *particular* cultures—that is, of the cultural varibles. His "laws"—for example, that culture is cumulaive, that man's control of energy is the ultimate cause f culture change, that technological changes cause ocial and ideological changes, that higher cultures dif-er in certain ways from lower ones—are merely descriptive generalizations of the kind that social science as made for a long time.

But the human mind is not irrelevant to problems of lture causality. If it were not a creative agent, culure would not change at all. White concedes that man's mentality is a factor in that the use of symbols, particularly language, enables him to perpetuate learned behavior and pass it on from one person to another. He fails to recognize that characteristically human rational and emotional responses force the cultural solutions of life into certain channeled and determinable directions. If culture were caused by culture alone, human nature being disregarded, cultural differences would appear to be random and whimsical. Any scientific determinism, however, must recognize that the human mind tends to solve similar problems in similar ways. The solution to practical problems, whether corralling game or taking the next step in higher mathematics, will be "reasonable," that is, predictable. In the nonrational portions of culture, such as interpersonal relations, it is the special human psychological processes, most of them unconscious, that integrate diversified behavior patterns and adapt new modes of behavior into self-consistent configurations. Culture is more than a mechanical summation of elements. It has a human organization. If nonhuman species with different inherent psychological processes had developed culture, it would be very different.

White's effort to find universal laws in the face of cultural diversity expectably leads to nothing very startling. His own logic prevents him from making the quest for laws a search for similar causes and similar results in particular situations. The equation should read: body × mind × particular habit × culture A = culture B. At any given time and place in cultural development the distinctive way in which the human mind reacts upon a particular culture will produce determinable changes. This will be duplicated under similar conditions. White's rejection of body, mind, and habitat as causal factors amounts merely to elaborate proof that one equals one —that cultural variations are explained by cultural variations.

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THE FRIENDLY SPIDERS

Webs in the Wind: The Habits of Web-Weaving Spiders. Winifred Duncan. xv + 387 pp. Illus. $4.50. Ronald Press, New York.

MISS DUNCAN begins the story of her spider-web researches at Provincetown, at the tip of Cape Cod, where she was caught at dusk in a rainstorm. Seeking shelter in the lee of an abandoned icehouse, she was attracted by dozens of small spiders, the intricate patterns of whose homes were revealed in all their beauty by the flashes of lightning. But that this adventure was not her initial acquaintance with these creatures is evidenced by her charming description of their anatomy and their ability to perform labors that seem incredible (unless we grant the possession of engineering ability), by her love and admiration for creatures so endowed, and by a plea to the reader who would crush such a marvel of creation.

Although our energetic author spent the next few weeks in tireless investigations into the spinning habits of many other kinds of spiders, each with its special type of food trap, and in scanning such authoritative books as she could come by, she found so many discrepancies, and so many unanswered questions, that she has since spent months of study in New Hampshire, California, and Louisiana, and between two and three years in several of the interior states of Mexico.

In the course of her studies Miss Duncan has met

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